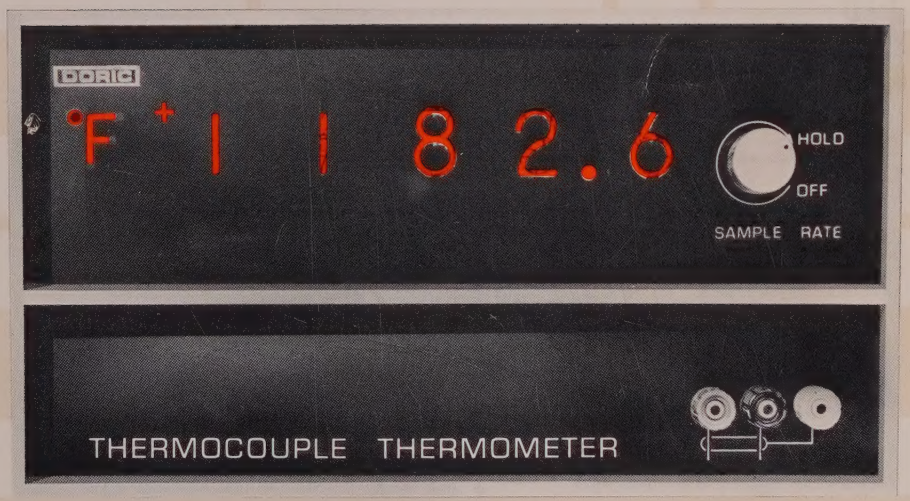
OWNER'S MANUAL

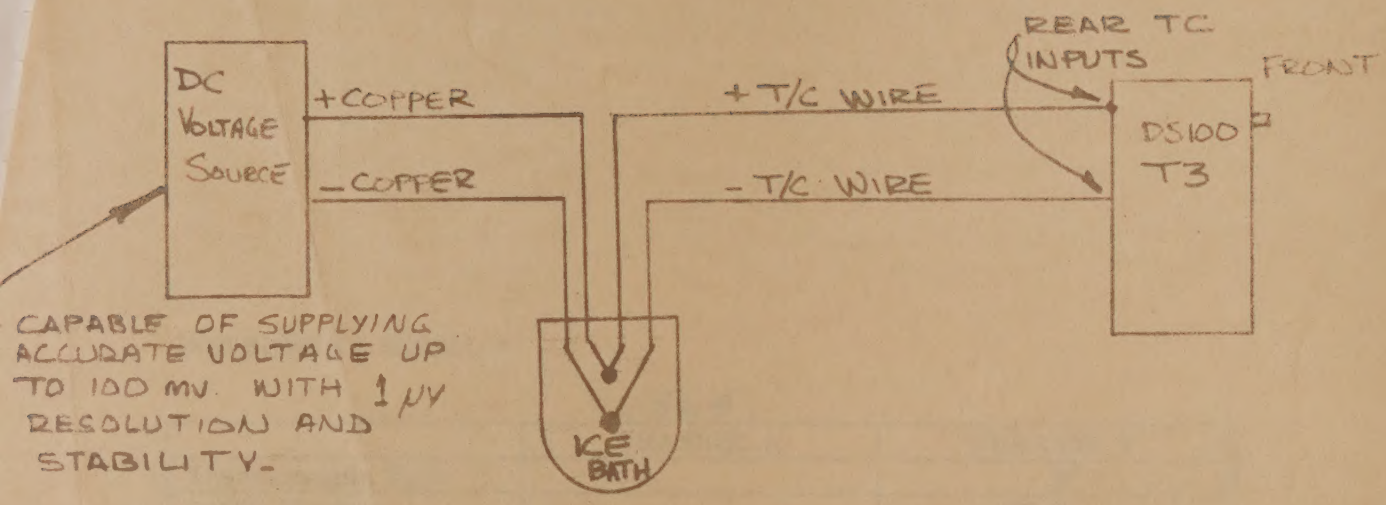
Return To J.H. Peters
X-2419



DIGITAL THERMOCOUPLE THERMOMETER

for process or test variable monitoring

DORIC SCIENTIFIC CORPORATION



RECOMMENDED CALIBRATION PROCEDURE DS-100-T3

1. Hook up test equipment as shown in figure above. (If no ice bath is available, one may be constructed by placing ice-cubes in a container with distilled water and continually stirring.

2. Pop open the plug-in and note the calibration instructions on the small sticker.

3. Dial in the noted DC voltage and adjust the noted pot to obtain the zero and full scale readings listed on the calibration sticker.

4. For alternate calibration procedures, see Section 4 of the manual.

FOREWORD

This manual is separated into two portions — the first dealing with Doric Scientific's series of digital thermocouple thermometers; the second portion being devoted to the DS-100 mainframe and its various plug-in options. Because the second portion contains many pertinent paragraphs applicable to the thermocouple theory of operation, it is recommended that a review of the mainframe portion be accomplished first.

TABLE OF CONTENTS

Paragraph		Page
	SECTION I — THE DS-100 DIGITAL THERMOCOUPLE THERMOMETER	
1-1	General Description	1-1
1-2	Operating Controls	1-2
1-2-1	Power/Sample Rate Knob	1-2
1-2-2	X and Y Function Select (T3D Only)	1-2
1-2-3	100 mv Range Pushbutton (T3D Only)	1-3
1-3	Features/Specifications — Doric DS-100-T3 Series	1-4
1-3-1	Performance Specifications	1-4
	SECTION II — INSTALLATION	
2-1	Unpacking Instructions	2-1
2-2	Thermocouple Connections	2-1
2-3	Grounding Considerations	2-2
2-4	Remote Programming via Range Lines	2-3
2-5	Analog Output Connections (Option)	2-3
	SECTION III — THEORY OF OPERATION	
3-1	Circuit Blocks, General	3-1
3-2	Circuit Block Description	3-1
3-2-1	Reference Junction (Optional)	3-1
3-2-2	Reference Junction Supply	3-4
3-2-3	Precision Reference Supply	3-4
3-2-4	Programmable Frequency Generator	3-5
3-2-5	Digital Programmer	3-6
3-2-6	Offset Pots	3-6
3-2-7	Analog-to-Digital Converter	3-7
	SECTION IV — CALIBRATION	
4-1	Test Equipment	4-1
4-2	Calibration Procedure	4-1
4-3	Cold Junction Compensator	4-4
4-4	Instrument Self-Check	4-5
4-5	Troubleshooting	4-5
	SECTION V — SCHEMATICS/PARTS LIST	
5-1	Drawing Index	5-1

LIST OF ILLUSTRATIONS

Figure		Page
1-1	Doric Scientific DS-100-T3D	1-1
1-2	Operating Controls	1-2
1-3	Self-Accuracy Check, T3D	1-3
1-4	T3D Plug-In Module	1-5
2-1	External Reference Junction	2-1
2-2	Connections; Grounded Thermocouple	2-2
2-3	Connections; Floating Thermocouple	2-2
2-4	Analog Diagram	2-4
3-1	Block Diagram	3-2
3-2	Timing Diagram	3-3
3-3	Reference Junction	3-4
4-1	Calibration Sticker	4-2
4-2	Calibration Pots, Board Locations	4-3
4-3	Troubleshooting Chart	4-5

SECTION I

THE DS-100-T3 DIGITAL THERMOCOUPLE THERMOMETER

1-1. GENERAL DESCRIPTION

The Doric Scientific T3 plug-in, together with the DS-100 digital indicator mainframe, form a fully automatic, solid-state digital thermocouple measuring instrument which displays the outputs of a wide variety of thermocouples directly in °F or °C. The instrument includes a microvolt level A/D converter; digital linearization; direct nixie display; and, as an option, reference junction compensation.

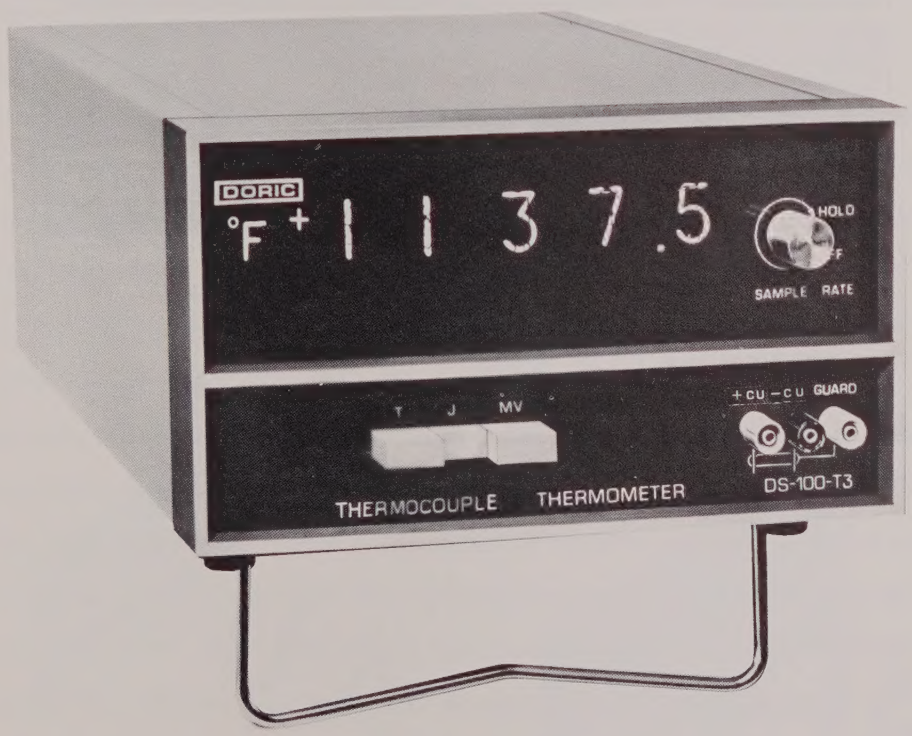


Figure 1-1. Doric Scientific DS-100-T3D

As is the case with all Doric Scientific plug-ins, depression of the latch located under the front bezel of the mainframe releases the module, allowing it to slide out 1-1/2 inches for access to calibration pots while the instrument remains in complete operation.

1-2. OPERATING CONTROLS

Doric offers two plug-ins for thermocouple measurements: the Model T3, which employs a single thermocouple function; and the Model T3D for dual function operation and DC voltage measurements.

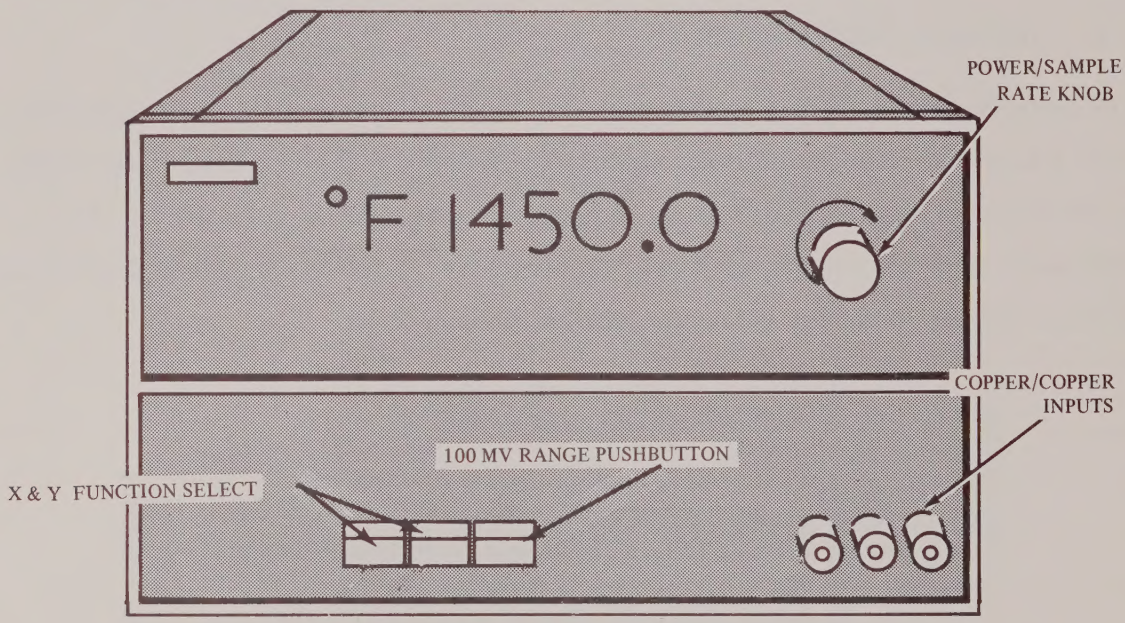


Figure 1-2. T3D Dual Function Controls

1-2-1. POWER/SAMPLE RATE KNOB

Regardless of the plug-in type, all Doric Scientific thermocouple thermometers retain the POWER/SAMPLE RATE knob located on the DS-100 mainframe front panel. As explained in the mainframe portion of the manual, when power is applied, the instrument begins encoding at the maximum sample rate when the knob is moved clockwise from the OFF position. As the control knob is moved further clockwise, the sample rate decreases until it reaches the extreme clockwise position (HOLD) where the meter holds the reading indefinitely. When using the I/O board, the control should be set to HOLD, so that the instrument only responds to external sample commands.

1-2-2. X AND Y FUNCTION SELECT (T3D ONLY)

On the Model T3D, two separate reference junctions (OPTIONAL) and digital linearization programs enable the instrument to measure two different types of thermocouples.

By depressing either of the two function select buttons, one of the reference junctions and linearization programs is chosen and that thermocouple measured. The X and Y buttons are normally labeled with the ISA type and range data.

1-2-3. 100 MV RANGE PUSHBUTTON (T3D ONLY)

When the 100 mv pushbutton is depressed, the instrument becomes an accurate digital microvoltmeter, measuring and displaying any input voltage up to ±120 mv full scale, with 10 μv per digit resolution. This DC measurement capability can be employed to greatly extend the usefulness of the instrument in a variety of applications, such as the reading of strain gage outputs; platinum sensors; and, with the use of an external reference junction, the reading of additional thermocouple outputs as a DC voltage.

Another novel use of the 100 mv range is to utilize the instrument to check the accuracy of its linearizer without the use of an external calibrator. One can introduce a stable voltage to the copper/copper inputs of the T3D while monitoring it on the 100 mv range. By referring to a millivolt-to-temperature conversion chart, the corresponding temperature for that voltage is determined. Then, by depressing either the X or Y function pushbutton, the instrument will read out the correct temperature equivalent of that voltage. (See Figure 1-3.)

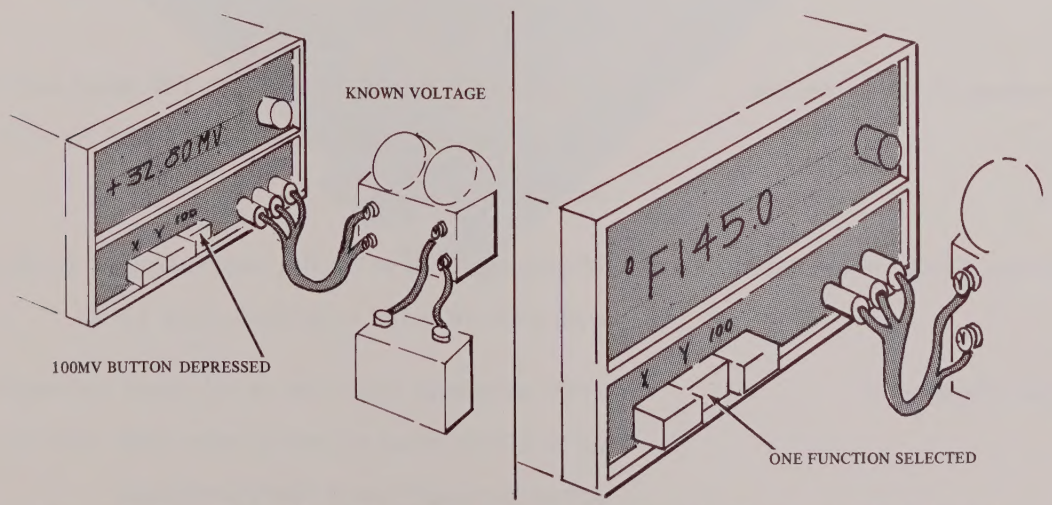


Figure 1-3. (Example) Measured input voltage: 32. 80 mv which is known to equal 1450° F. (For Type K — Chromel-Alumel thermocouple with 32° F reference.) Pressing Function Select Button, meter reads out proper temperature figure, plus or minus the tolerance of the instrument.

1-3 FEATURES/SPECIFICATIONS — DORIC DS-100-T3 SERIES

The Doric thermocouple thermometer features several outstanding design characteristics, including a revolutionary zero-drift correction circuitry which automatically re-zeros itself between each encoding, ensuring the customer of drift-free performance. The instrument also features a digital linearization technique to convert the non-linear thermocouple millivolt output to a direct temperature readout in either Farenheit or Celcius. Guarded differential input circuitry is another prominent design feature. In addition, the input signal is fed through a two-pole input filter and integrated for 100 ms. This results in a digital display practically unaffected by common mode or normal mode noise. Stability is further enhanced by a self-compensating analog-to-digital conversion technique dependent solely on the Zener reference voltage stability.

1-3-1. PERFORMANCE SPECIFICATIONS

Input Circuit:	Guarded, differential.
Measurement Method:	Automatic zeroing, dual slope integration.
Linearization:	100% digital with no analog approximation circuits; 10 segments minimum.
Common Mode Rejection:	140 db at 55 Hz and above with 100 ohms unbalance, with or without cold junction; 250 VDC or P-P AC CMV.
Normal Mode Noise Rejection:	Minimum 62 db at 59 Hz, increasing at 18 db/octave, with infinite noise rejection every 10 Hz.
Input Impedance:	1000 megohms minimum at all times (potentiometric); up to 10000 ohms extension wire with less than . 05° error for base-metal thermocouples.
Temperature Stability:	±. 0025% rdg/° F, ±. 02° F/° F for Types J, K, T, Y, E; Types R, S, and B: ±. 005% rdg/° F, ±. 1° F/° F.

Figure 1-4. Model T3D Thermometer Plug-In.

Long Term Stability:	.01% rdg or 1 digit for 30 days; .03% rdg or 3 digits, 6 months.
Zero Drift:	None.
Speed:	500 ms.
Overload:	100V continuous without damage.
Backlash:	None.
Internal Reference:	Stabilizer Zener, temp. compensated.
Display:	200,000 hour life, Burroughs Nixie indicators, smooth non-segmented numerals. Readable to 40 feet. Storage to prevent blur.
Circuitry:	All silicon, solid state with no mechanical devices at all; all integrated circuits are standard.
Size:	Half-rack, 4.5 by 8.5 inch panel, 12 pounds.
Cold Junction Accuracy:	±.25° F with ambient of 77 ±2° F; temperature effects of ±.015° F/° F from 50 to 104° F.
Calibration:	Two-point calibration: At ice point and full scale; individual segment calibration not required as they are digitally established and cannot drift.
Repeatability:	±1 digit.

SECTION II

INSTALLATION

2-1. UNPACKING INSTRUCTIONS

Instructions relative to proper unpacking; receiving inspection; power requirements; bench mount instruments; rack mounting; and repacking procedures will be found on pages 2-1 through 2-9 of the DS-100 mainframe portion of the manual. It is important that these pages be reviewed prior to instrument hook-up.

2-2. THERMOCOUPLE CONNECTIONS

A terminal strip located on the rear panel is supplied with each DS-100-T3 that contains the optional reference junction. Thermocouple wires are attached to this strip. If the DS-100-T3 is a single range unit, only the +Y and -Y terminals are used. If a shield is also used, hook it to the guard jack on the rear panel. If the DS-100-T3 is a dual range unit, the X and Y terminals correspond to the front panel pushbuttons. (The pushbuttons will be labeled with the thermocouple type.) The extreme left-hand pushbutton is for the X terminal; the next one for the Y.

Instruments without the optional integral reference junction must be used with external reference junctions for accurate operation (see Figure 2-1). Unless otherwise specified, all instruments are set up for use with 32°F reference junctions.

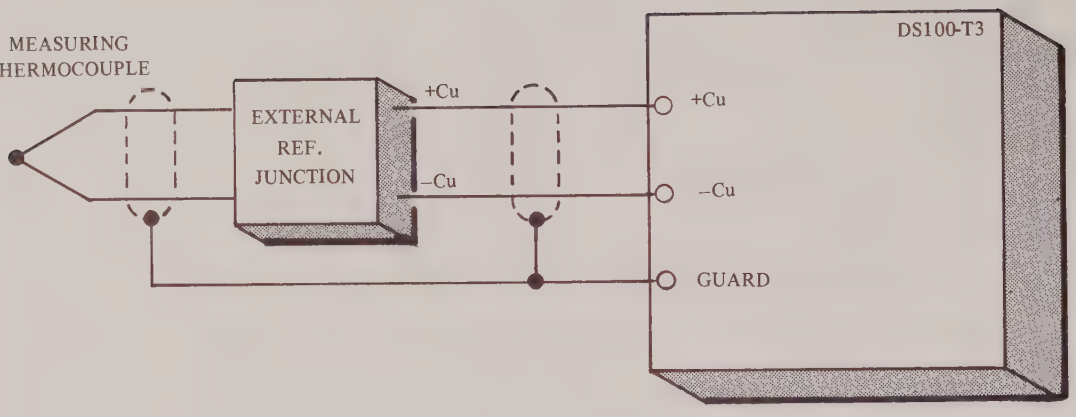


Figure 2-1. External reference junction used with the DS-100-T3.

2-3. GROUNDING CONSIDERATIONS

For noise-free operation, the measuring circuit should be connected to earth ground at only one point.

a. If the thermocouple is grounded, the circuit shown in Figure 2-2 should be employed.

b. If the thermocouple is completely floating, the circuit shown in Figure 2-3 will be most advantageous.

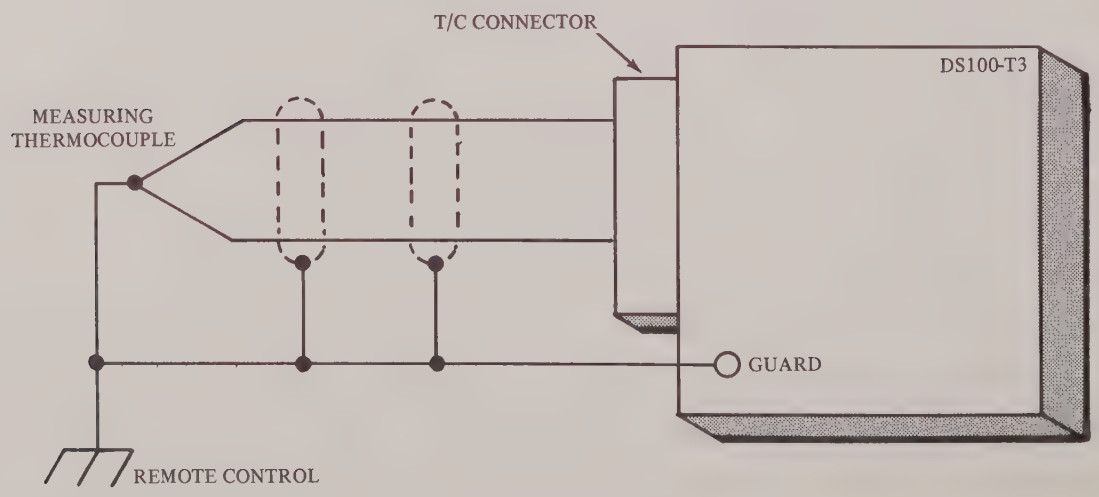


Figure 2-2. Grounded Thermocouple.

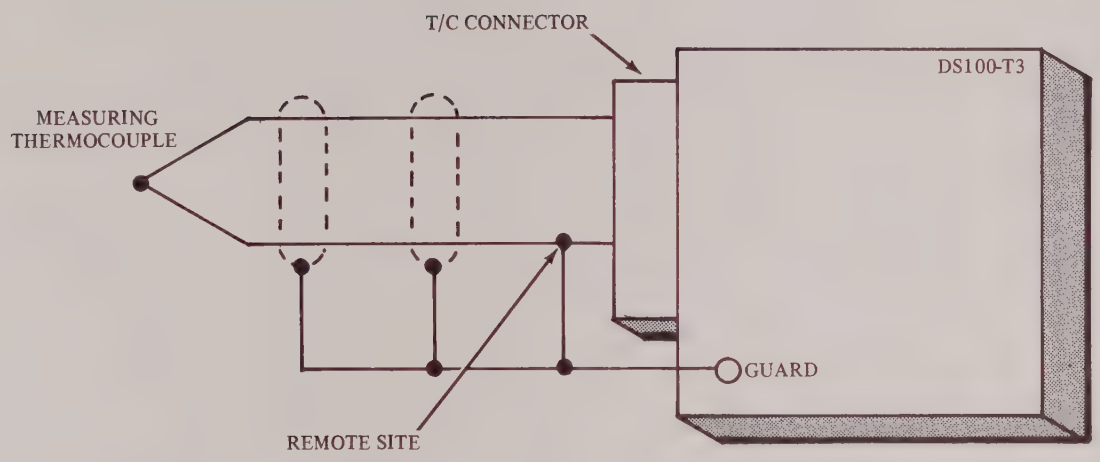


Figure 2-3. Floating Thermocouple.

2-4. REMOTE PROGRAMMING VIA RANGE LINES

It is possible to remotely program the three T3D functions via range lines feeding into the I/O board. The two lines are labeled RANGE 1 and RANGE 2. RANGE 1 controls curve X and RANGE 2 controls curve Y. When programming remotely, all pushbuttons must be DISENGAGED.

When either one of the two temperature functions is selected remotely, the other channel is obviously dormant. When neither channel is being remotely programmed, the instrument is in the 100 mv range function.

A careful review of paragraphs 1-3-9, 1-3-9-1 and 1-3-9-2 of the mainframe portion of the manual will enable the user to fully understand the remote capabilities of the instrument. Information regarding external connections will be found in paragraphs 2-8 and 2-9 of the mainframe portion.

2-5. ANALOG OUTPUT CONNECTIONS (OPTION)

When requested, a low impedance (100Ω) analog output is supplied by means of a connector (J7) at the rear of the instrument. Analog output HI is pin 9; analog output LO is pin 10. Because analog output LO is at the same potential as the T3 LO input, it is mandatory that these outputs be used with floating, differential recorders (or other output devices). The connection should be made with a two-wire plus shield coax, with the shield connected to J7, pin 8, and at the recorder end if the recorder is guarded. If the recorder is not guarded, the shield should be connected only at J7, pin 8.

Analog outputs are directly proportional to the millivolt input of the T3, being amplified 100 times ±1%. The 1% tolerance is inconsequential as the Gain Adjust on the recording device is more than adequate to compensate for this.

At ambient (23°C ±4°C), the output of the analog amplifier will typically display ±10 mv of zero offset. This also is of no consequence as this error is easily removed with the offset pot on the recording device.

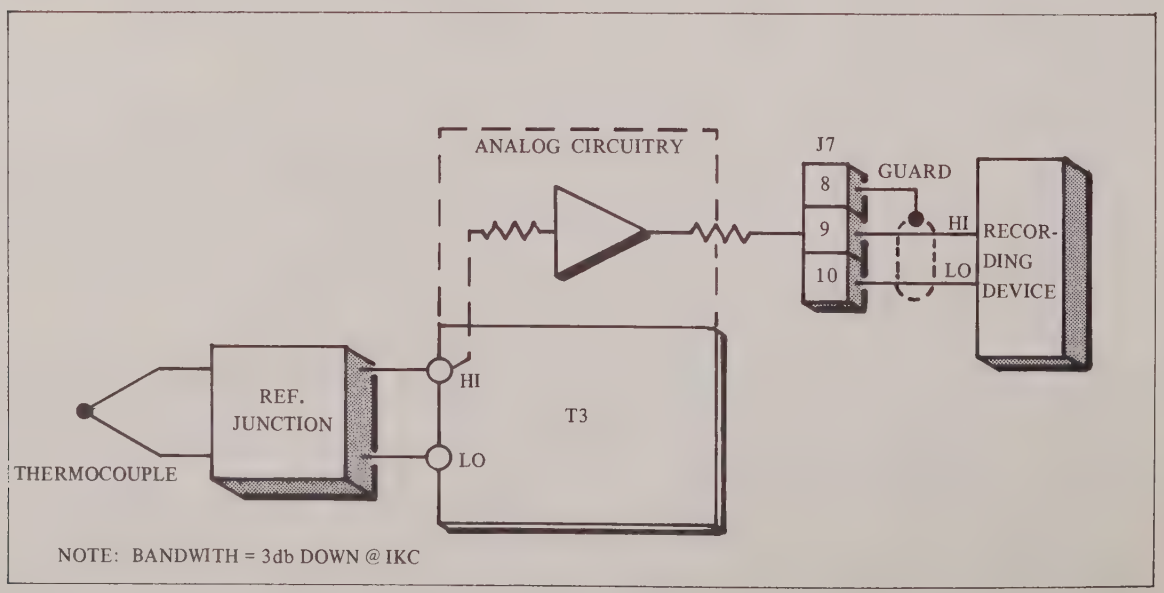


Figure 2-4. Analog Diagram.

III

THEORY OF OPERATION

3-1.

In order to display the thermocouple output as temperature, the DS-100-T3 employs a programmable frequency generator, a digital programmer, a display counter and a voltage-to-time converter with appropriate signal conditioning. As shown in Figures 3-1 and 3-2, a constant 100 KHz is fed into the display counter through the gates during T_1 time. During T_2 time, a series of selected frequencies is fed to the counter for a time proportional to the thermocouple voltage (the V to T converter develops this time).

The frequency profile is shown in Figure 3-2D. Figure 3-2E shows how the counts in the display counter are accumulated non-linearly due to the varying frequency profile. This non-linearity compensates for the non-linearity of the thermocouple output. Figure 3-1 shows how the varying frequency profile is formed. For every N counts into the display counter, a count is sent to the segment counter. The segment counter causes a set of frequencies to be selected via the diode matrix. The digital programmer (segment counter + diode matrix) causes the frequency generator to put on new frequencies periodically up until the time proportional to E_{in} is reached. The number in the display counter is then displayed.

3-2. CIRCUIT BLOCK DESCRIPTION

The following circuit blocks are used in the Doric digital thermocouple thermometer:

3-2-1. REFERENCE JUNCTION (OPTIONAL)

The reference junction used in the T3 series is an encapsulated automatic cold junction compensator providing the equivalent of an ice bath temperature of 32° F. It contains a self-compensating bridge network as shown in Figure 3-3.

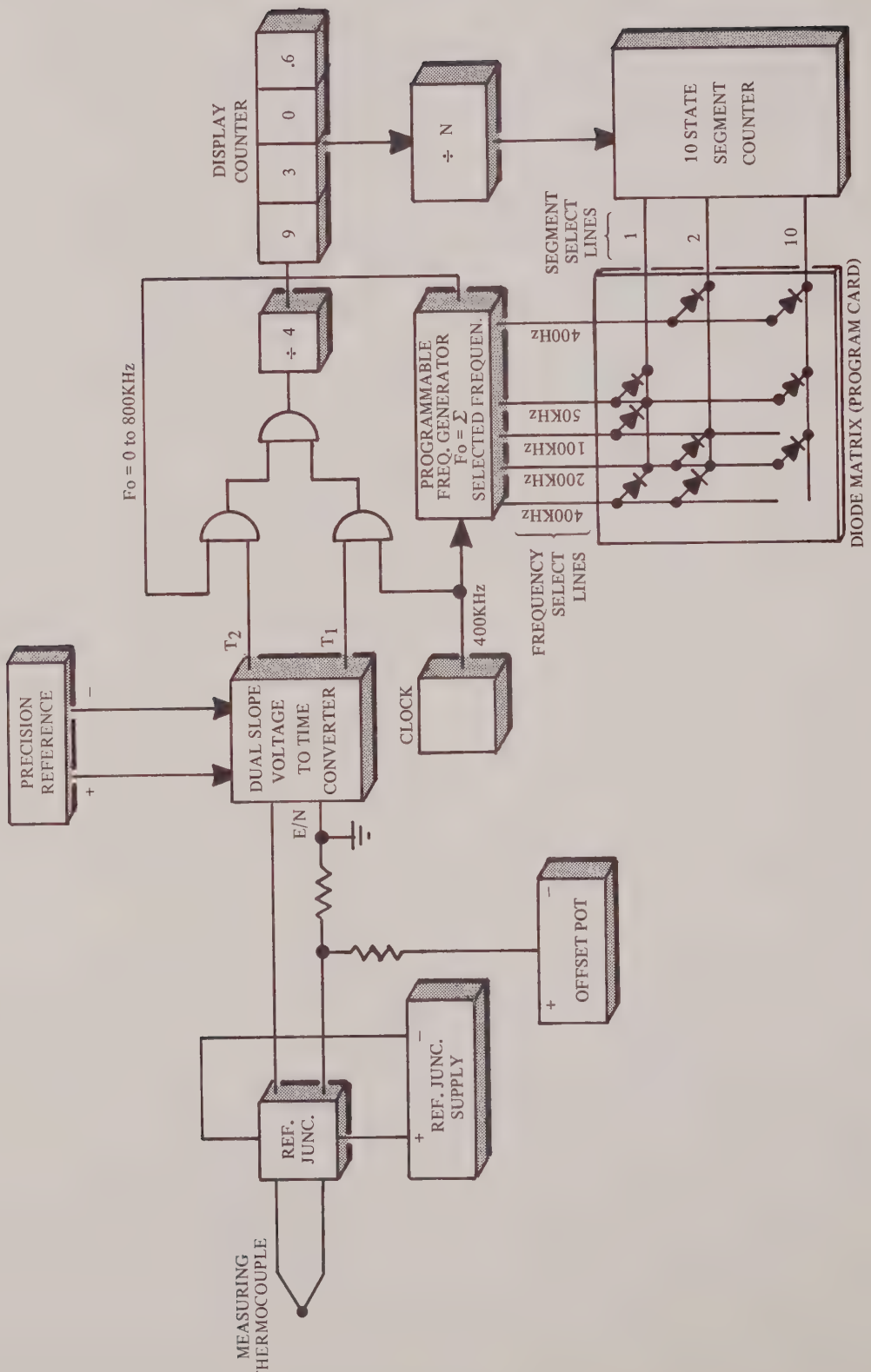


Figure 3-1. Block Diagram.

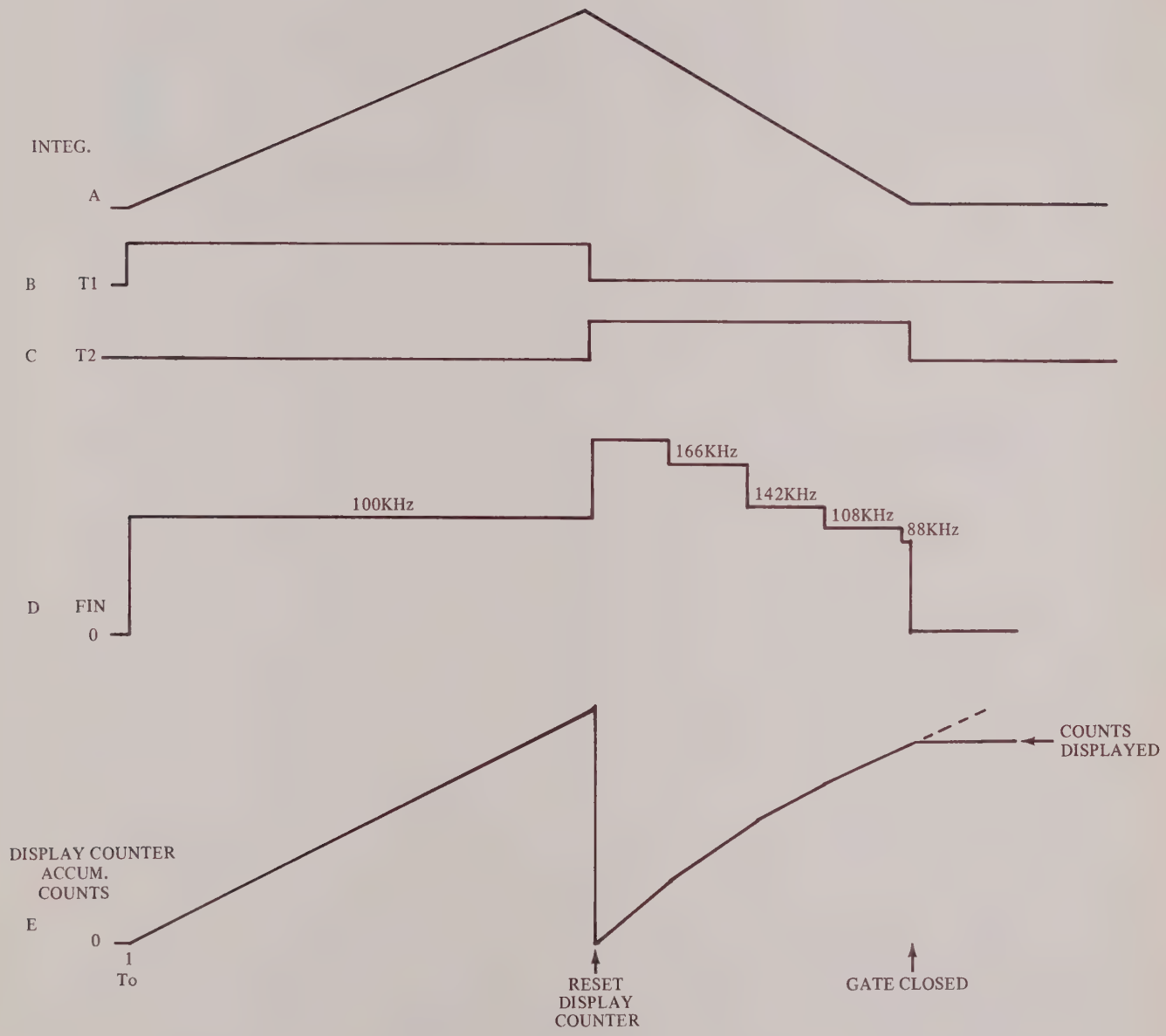


Figure 3-2. Timing Diagram.

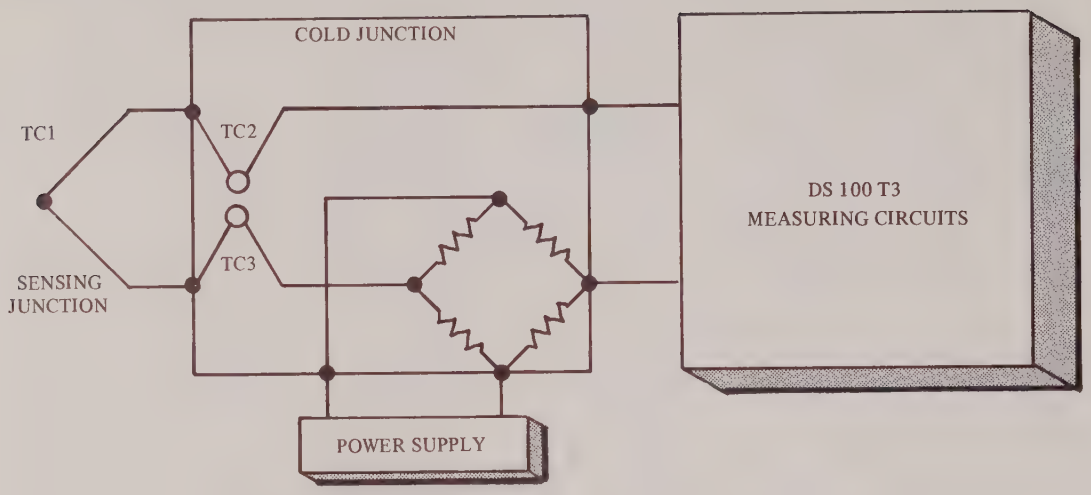


Figure 3-3. Reference Junction.

As the ambient temperature surrounding T. C. 2 and T. C. 3 varies, a thermally generated voltage appears and produces an error in the output. However, an equal and opposite voltage is automatically introduced; the series bridge cancelling out the thermal error and maintaining the correct T. C. 1 output over a wide ambient temperature range.

The cold junction provides the interface between the thermocouple wires and the instrument's copper inputs without the introduction of any secondary thermocouple errors.

3-2-2. REFERENCE JUNCTION SUPPLY

The power source for the reference junction is a floating supply formed by a two transistor, 300 KC multivibrator (Q10 ± Q11) driving the primary of a resonant transformer. The secondary of the transformer is full wave rectified, filtered and fed into a Zener regulator. The output of the regulator supplies the reference junction.

3-2-3. PRECISION REFERENCE SUPPLY

This precision Zener supply consists of a temperature-compensated constant current supply delivering an accurate current to an aged and temperature-compensated Zener

diode. The supply is used as the standardizing voltage for the Analog-to-Digital converter and is fully described in Section IV, Paragraphs 4-6-2, 4-6-2-1, 4-6-2-2, and 4-6-2-3 of the mainframe portion of the manual.

Unlike the reference divider described in Paragraph 4-6-2-4 of that section, however, the DS-100-T3 reference divider puts out voltages of 15 mv, 30 mv, 60 mv and 100 mv which are adjustable by range calibration potentiometers R9, R3, R28 and R24 respectively (Schematic 100-252-).

3-2-4. PROGRAMMABLE FREQUENCY GENERATOR*

In order to linearize a non-linear thermocouple function (convert the non-linear thermocouple output to a direct temperature readout), some part of the A to D converter must be made non-linear, but in a highly precise and reproducible way. The analog-to-digital conversion is accomplished by the dual-slope technique as explained in Section 4-1 of the mainframe portion of the manual. As can be seen by reviewing the last two equations on page 4-2 of that section, if the fixed-interval clock pulses (f_{clk}) are constant throughout t_1 and t_2, their effects then cancel out. However, if f_{clk} is varied during t_2 at equal increments of the number in the display counter, the result will then be a non-linear readout.

To accomplish this, two things are needed: (1) A digitally programmable frequency generator and (2) a digital programmer.

The frequency generator employed in the Doric DS-100-T3 derives its primary frequency from a 400 Kc L-C oscillator formed by integrated circuits Z14A and Z14B (schematic 100-252-). This primary frequency is, in turn, divided down by a string of J-K flip-flops (integrated circuits Z15 - Z19). These develop octave related frequencies, some of which are summed together under the control of the programmer, by transistor Q8 into integrated circuit Z3D (if a second set of frequencies is required, Q9 is used).

*Patent Pending.

The summed frequencies are then fed to the A to D converter via integrated circuits Z2A, Z2B and Z3A. During time t_1 (refer to Paragraph 4-1, Section IV, mainframe portion of manual), the clock, being controlled by integrated circuits Z3B, Z3C and Z3D, bypasses the summer and is fed directly to the A to D converter.

3-2-5. DIGITAL PROGRAMMER

As noted earlier, a digital programmer is needed in conjunction with the frequency generator. The purpose of the programmer is to periodically change the frequency going to the A to D converter during t_2. (The effect of this frequency change is to change the meter sensitivity directly as a function of the selected frequency.) The programmer implements these changes by picking off a frequency from the display counter and feeding it through appropriate frequency counters (integrated circuits Z6A, Z6B, Z9A, Z9B, Z10A) to a BCD segment counter. The dividers control the number of counts which must be accumulated in the display counter before the frequency is changed. The BCD counter, in turn, feeds a BCD to ten-line decoder, Z12. Each of the ten lines from this decoder selects an 11-bit binary word contained in the diode matrix. When a given one of the ten decoder lines is negative, its related binary word controls the frequencies which are allowed through frequency selection gates G1 through G11 to the summer Q8. As the segment counter steps from 1 through 10, ten separate sets of frequencies are selected by the diode matrix in the programmer. (The diode matrix, the frequency selection gates, and the offset pots are on the program card 100-035.) When a second curve is desired, frequency selection gates G12 through G22 are used.

3-2-6. OFFSET POTS

The offset pots provide a precise voltage which is inserted in series with the reference junction output. The purpose of the pots is to provide a readout equal in degrees to the simulated reference junction temperature when the reference junction output is zero volts.

3-2-7. ANALOG-TO-DIGITAL CONVERTER

The theory of operation for the analog-to-digital converter is covered extensively in the second portion of the manual.

IV

CALIBRATION

NOTE

The DS-100-T3 Thermocouple Thermometer should be allowed to warm up for one hour prior to calibration. After warm-up, release the plug-in latch which will allow the unit to slide out about 1-1/2 inches, giving access to the calibration controls. (NOTE: The plug-in should not be left extended except while actually adjusting the controls since the air circulation will upset the internal thermal balance.)

4-1. TEST EQUIPMENT

A DC voltage calibrator capable of supplying accurate voltages up to 100 millivolts, with better than 1 microvolt resolution and stability is required. Low output impedance DVM calibrators are not suitable as their noise is typically 10-50 microvolts. Generally, the only suitable equipment is a low-thermal microvolt pot such as Honeywell 2768 or 2773, or a .005% type DVM calibrator in conjunction with a ratio set such as ESI 1063B plus an ice bath.

4-2. CALIBRATION PROCEDURE

As suggested earlier, the instrument should be allowed an hour warm-up prior to calibration. After warm-up, adjust the sample rate control for the desired repetition rate.

If the meter is a dual curve unit (DS-100-T3D), calibrate the instrument by accomplishing the following steps:

a. Depress the 100 mv range button.

CALIBRATION PROCEDURE				
	X CHANNEL		Y CHANNEL	
INPUT				
ADJUST				
READ				

In each column, (1) introduce the noted input, (2) adjust the noted pot to (3), obtain the noted reading.

NOTE: Listed readings are such to optimize accuracy when reading thermocouple outputs. When applying millivolts directly to the copper-copper inputs, up to 1/2° of additional error could possibly result.

Figure 4-1. Calibration Sticker for T3 Plug-In.

b. Short the input terminals (+Cu, -Cu, Guard), using a copper bus wire.

c. Open the plug-in and adjust the μ volt offset control for a display of +00.00 mv.

d. Depress the left-hand (X channel) pushbutton.

e. Adjust the X 32° OFFSET pot to obtain the reading indicated on the calibration sticker attached to top front of the T-3 plug-in.

f. Depress the middle (Y channel) pushbutton.

g. Adjust the Y 32° OFFSET pot to obtain the reading indicated on the calibration sticker.

h. Depress the left (X channel) pushbutton.

i. Remove short from the +Cu, -Cu inputs. Apply a DC calibrator to the +Cu, -Cu inputs. Keep the guard shorted to -Cu. Dial the larger input voltage indicated on the calibration sticker for the X channel.

j. Adjust the indicated X channel pot until the indicated temperature reading is obtained.

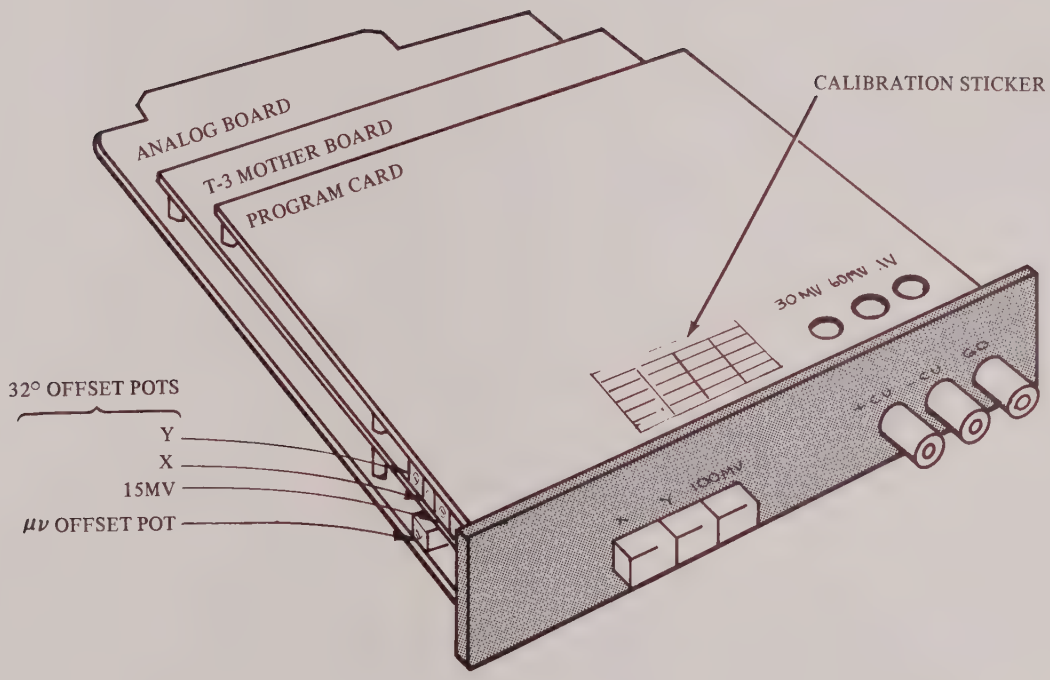


Figure 4-2. Calibration Pots, Board Location.

k. Depress the middle (Y channel) pushbutton.

l. Apply the larger indicated voltage for the Y channel.

m. Adjust the indicated (Y channel) pot until the indicated temperature reading is obtained.

n. Depress the 100 mv pushbutton.

o. Apply +100.00 mv to the +Cu, -Cu inputs.

p. Adjust the 100 mv pot until a reading of +100.00 mv is obtained.

q. Close the instrument and recheck calibration after warm-up.

If the meter is a single range DS-100-T3, calibration is accomplished by the following steps:

a. Short the input terminals (+Cu, -Cu, Guard), using a copper bus wire.

b. Adjust the Y 32° OFFSET pot to obtain the reading indicated on the calibration sticker.

c. Apply the larger indicated voltage for the Y channel.

d. Adjust the Y channel pot until the indicated temperature reading is obtained.

If the meter is a single range DS-100-T3 with 0°C reference, calibrate by accomplishing the following steps:

a. Short the input terminals (+Cu, -Cu, Guard), using a copper bus wire.

b. Open the plug-in and adjust the microvolt offset pot for a display of all zeros.

c. Remove the short from the input and introduce the input voltage noted on the calibration sticker. Adjust the noted pot (per sticker instructions) until the noted reading is displayed.

4-3. COLD JUNCTION COMPENSATOR

For instruments equipped with the internal reference junction compensator, it may be desirable to check the compensator's ice-point accuracy.

4-3-1.

Connect a thermocouple to the rear thermocouple input connectors. Place the sensor in a stable ice bath with accuracy better than the thermometer's resolution. (For example, ice bath should be accurate to 50 millidegrees F if thermometer has 100 millidegrees resolution.)

Assuming calibration is done within ambient reference conditions of 77°F ±2°F, the readout should be within ±0.25°F of reading printed on calibration sticker.

4-4. INSTRUMENT SELF-CHECK

It is possible to quickly check the instrument's accuracy at any point on the temperature range by following the procedure outlined in Paragraph 1-2-3 and Figure 1-3, Section I.

4-5. TROUBLESHOOTING

By referring both to the DS-100 mainframe troubleshooting charg in the second portion of the manual and to the following T3 chart, most problems which may occur in the instrument should be readily uncovered.

SYMPTOM	PROBABLE CAUSE	PROCEDURE
Temp reading goes down as T/C temp goes up	T/C wires reversed as they go into terminal strip	1. Correct wiring
Temp reading high by about 30° to 40°F	Reference junction supply failure	1. Check for 6V ±.1% across reference junction mounted on rear rail. 2. If 6V is not present troubleshoot supply. Refer to Para. 3-2-2.
	T/C wires connected to Cu-Cu inputs	1. Connect T/C wires to T/C terminal strip
Temp reading noisy	Shipping screw not removed	1. Remove screws in front of front feet. See Section II
	Guard not connected measuring circuit	1. Connect Guard to LO terminal
Temp reading noisy when using T/C inputs but quiet on millivolt inputs to Cu-Cu terminals	Reference junction supply intermittent	1. Check for 6V ±.1% across reference junction mounted on rear rail 2. Check reference junction wiring continuity 3. If 6V is not present, troubleshoot supply. Refer to Para. 3-2-2

Figure 4-3. Troubleshooting Chart

SYMPTOM	PROBABLE CAUSE	PROCEDURE
Temp readings correct only at the low end. Readings are proportional to millivolts in instead of temperature	Failure in digital programmer (segment counter) circuit	1. Check ÷N circuits (Fig. 3-1 and Para. 3-2-5.) Confirm that there is some frequency in (Pins E1 or E2) and a lower frequency out (Pin 2, Z5A) 2. Check gate Z5A and segment counter Z12 3. Check segment decoder Z15
Temp readings are nonlinear. Not proportional to temp or millivolts	Failure in diode matrix	1. Check program card for cracked diodes or bent connector pins. Refer to Fig. 3-1 and Para 3-1
	Failure in binary divider	Check flip-flops Z15B through Z19A. Each flip-flop should divide its input frequency by 2
+ or - temp will not calibrate	Precision reference supply not operating correctly	Troubleshoot the precision reference supply using Para. 3-2-3 and Schematic 100-252
Nixies blur or dim out	Top digital board not firmly seated in connector possibly due to installation of I/O board	Unplug power cord, remove rear casting and slide out top cover. Next, loosen digital board shipping screws and firmly insert digital board into connector. Retighten shipping screws and replace cover and rear casting

NOTE: It is good procedure to check the power supply voltages and loads as covered in mainframe manual Section 6-5 before proceeding with any of the above troubleshooting programs.

Figure 4-3. Troubleshooting Chart (continued)

SECTION V

SCHEMATICS/PARTS LIST

5-1. DRAWING INDEX

Parts List, T3 Series Chassis
Parts List, T3 Series Motherboard
Parts List, T3 Series Analog Board
Parts List, T3 Series Program Board

Schematic, T3 Series Motherboard; Program Board

Assembly, T3 Series Motherboard
Assembly, T3 Series Analog Board

NOTE

Documentation pertaining solely to the DS100 portion of the instrument will be found in the mainframe part of the manual.

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	T3 Motherboard Assembly	Doric	100-468-09	100-468-09	1		
	Circuit Board	Doric	100-252-06	100-252-06	1		
	Integrated Circuit	Motorola	MC776P	965-502-00	10		
	Integrated Circuit	Motorola	MC717P	965-503-00	6		
	Integrated Circuit	Fairchild	995879	965-501-01	1		
	Integrated Circuit	Fairchild	996079	965-501-03	1		
	Integrated Circuit	Fairchild	741	965-506-00	1		
	Transistor, 2N3393	GE	2N3393	962-339-30	2		
	Transistor, 2N3606	GE	2N3606	962-360-30	2		
	Transistor, 2N3638	Fairchild	F2N3638 732	962-363-80	1		
	Transistor, 2N3877A	GE	2N3877A	962-387-71	1		
	Transistor, 2N4250	National SC	2N4250 6743	962-425-00	1		
	Transistor, FET	Amelco	U1742	100-722-00	4		
	Diode, 1N753	Continental Devices	1N753	961-075-31	1		
	Diode, Zener, Special	Doric	100-721-01	100-721-01	1		
	Diode, 1N914	Continental Devices	1N914	961-091-40	23		
	Capacitor, .22 mfd, poly carb	Elpac	B1A224J	911-032-24	2		
	Capacitor, .01 mfd, disc	RMC	TA. 01Y5U	900-021-04	4		
	Capacitor, .001 mfd, disc	RMC	BA. 001Y5U	900-081-03	4		
	Capacitor, .068 mfd, poly carb	Elpac	B1A683J	911-036-83	1		
	Capacitor, 22 pf, disc	RMC	22NPO	901-012-20	1		
	Capacitor, 510 pf, Duramica	Elmenco	DM15-J11J	915-035-11	1		
	Capacitor, 360 pf, Duramica	Elmenco	DM15-361J	915-033-61	1		
	Capacitor, .002 mfd, disc	RMC	BA. 002Z5U	900-082-03	1		
	Capacitor, Trimmer	Arco	469	914-100-00			

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	Resistor, Wire Wound						
	.05%, 55.55Ω	Mektron	Series C4	934-215-59	2		
	.05%, 100.88Ω	Mektron	Series C4	934-211-01	1		
	.05%, 137.00Ω	Mektron	Series C4	934-215-59	1		
	.05%, 20K	Mektron	Series C4	934-212-03	2		
	.05%, 36.65K	Mektron	Series C4	934-213-63	1		
	.05%, 40K	Mektron	Series C4	934-214-03	2		
	Resistor, Metal Film						
	1%, 1.78K	Corning	RN60C Series	920-417-81	1		
	1%, 51.1K	Corning	RN60D Series	920-351-12	1		
	1%, S.O.T.	Corning	RN60D Series	-	4		
	Resistor						
	1/4W, 5% Carbon, 110Ω	Allen-Bradley	CB1115	942-201-11	3		
	1/4W, 5% Carbon, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
	1/4W, 5% Carbon, 1K	Allen-Bradley	CB1025	942-201-02	6		
	1/4W, 5% Carbon, 2.2K	Allen-Bradley	CB2225	942-202-22	7		
	1/4W, 5% Carbon, 3.3K	Allen-Bradley	CB3325	942-203-32	2		
	1/4W, 5% Carbon, 4.7K	Allen-Bradley	CB4725	942-204-72	6		
	1/4W, 5% Carbon, 6.2K	Allen-Bradley	CB6225	942-206-22	2		
	1/4W, 5% Carbon, 10K	Allen-Bradley	CB1035	942-201-03	6		
	1/4W, 5% Carbon, 22K	Allen-Bradley	CB2235	942-202-23	5		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	Resistor,						
	1/4W, 5% Carbon 220K	Allen-Bradley	CB2245	942-202-24	2		
	1/4W, 5% Carbon, 330K	Allen-Bradley	CB3345	942-203-34	1		
	1/4W, 5% Carbon, 470K	Allen-Bradley	CB4745	942-204-74	1		
	1/4W, 5% Carbon, 1 Meg	Allen-Bradley	CB1055	942-201-05	4		
	1/4W, 5% Carbon, 22 Meg	Allen-Bradley	CB2255	942-202-26	3		
	Resistor, Variable, 10Ω	CTS	P115R 100A	960-011-00	3		
	Resistor, Variable, 1K	Beckman	79PR1K	960-011-02	1		
	Resistor, Variable, 5K 4TR	Centralab	ZELAFK 0001-AD1	960-015-02	4		
	Choke, Z40 μh	Delvin	1537-94	967-005-01	1		
	Pins, mating	Elco	02-060-114-6200	973-080-01	89		
	Jumpers	-	-	-	5		
	Feedthrus	-	-	-	21		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
Schematic 100-625-06	Analog Board Assembly						
	Circuit Board, Analog	Doric	100-225-04	100-225-07	1		
Z1	Integrated Circuit	-	-	965-506-00	1		
Z3,4,5	Integrated Circuit, C μL	Fairchild	91428-751	965-500-00	3		
Q17, 18, 23, 24	Transistor, FET - High Leakage	Amelco	U1742	100-722-00	4		
Q3-5	Transistor, FET - Low Leakage	Amelco	U1742	100-732-00	11		
Q6A, 6B	Transistor, Dual	-	-	100-725-00	1		
Q7, 8, 12, 15, 19, 21, 48	Transistor, 2N4250	National SC	2N4250	962-425-00	7		
Q9,44	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	2		
Q16	Transistor, 2N3567	Fairchild	F2N3567814	962-356-70	1		
Q11, 22, 25-30	Transistor, 2N3877A	G. E.	2N3877A	962-387-11	12		
Q10, 13, 14, 20, 45, 47	Transistor, 2N3393	G. E.	2N3393	962-339-30	6		
Q49	Transistor, 40406	RCA	40406	964-040-02	1		
Q46	Transistor, 40347	RCA	40347	964-040-00	1		
CR1-5, 10, 11, 13-17, 35-40	Diode, 1N914	Continental Devices	1N914	961-091-40	19		
CR6-9	Diode, Zener, 6. 2V	Continental Devices	1N753A	961-075-31	4		
CR41, 42	Diode, Zener, 24V	Continental Devices	1N970B	961-097-02	2		
C4	Capacitor, . 068 μFD, 10%, Polycarb	Elpac	B1A683J	911-036-83	1		
C2	Capacitor, . 33 mfd, Polycarb	Elpac	B5A334	911-033-034	1		
C6	Capacitor, . 0047 μF, 10%, Mylar	Elpac	ZD5A472J	912-074-72	1		
C7, 8, 19, 21, 22, 24-26	Capacitor, 100 pf, 10%, Disc	RMC	JL100X5F	901-011-01	8		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
C5,20	Capacitor, .001 μFD, 20%, Disc	RMC	BA .001Y5U	900-081-03	2		
C3,9,11, 14,16,18, 27-30	Capacitor, .01 μFD, 20%, Disc	RMC	TA .01Y5U	900-021-04	10		
C12	Capacitor, .22 μFD, 10%, Polystyrene	Elpac	PD5A224K	913-042-24	1		
C17	Capacitor, .22 μFD, 10%, Polycarb	Elpac	B1A224J	911-032-24	1		
R83	Resistor, Metal Film, 1%, 56.2Ω	Corning	RN60D Series	920-356-29	2		
R123,124	Resistor, Metal Film, 1%, 215Ω	Corning	RN60D Series	920-321-50	2		
R126,127	Resistor, Metal Film, 1%, 8.25K	Corning	RN60D Series	920-382-51	2		
	Resistor, Metal Film, 1%, 10.2Ω	Corning	RN60D Series	920-310-29	1		
	Resistor, Metal Film, 1%, 133Ω	Corning	RN60D Series	920-313-30	1		
R16, 25	Resistor, Metal Film, 1%, 68.1K	Corning	RN60D Series	920-368-12	2		
	Resistor, Metal Film, 1%, 113Ω	Corning	RN60D Series	920-311-31	1		
	Resistor, Metal Film, 1%, 39.2K	Corning	RN60D Series	920-339-22	1		
R119	Resistor, Metal Film, 1%, 178K	Corning	RN60D Series	920-317-83	1		
R41	Resistor, Metal Film, 1%, 619K	Corning	RN60D Series	920-361-93	1		
R19,39,42, 122	Potentiometer, 5K, 4TR	Centralab	ZELA FK0001 AD1	960-015-02	4		
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1		
R29	Resistor, 1/4W, 5% Carbon, 47Ω	Allen-Bradley	CB4705	942-204-70	1		
R61,108, 115	Resistor, 1/4W, 5% Carbon, 68Ω	Allen-Bradley	CB6805	942-206-80	3		
R51,106, 107	Resistor, 1/4W, 5% Carbon, 110Ω	Allen-Bradley	CB1115	942-201-11	3		
R37,38	Resistor, 1/4W, 5% Carbon, 150Ω	Allen-Bradley	CB1515	942-201-51	2		
R110,114, 49, 130	Resistor, 1/4W, 5% Carbon, 390Ω	Allen-Bradley	CB3915	942-203-91	2		
R30	Resistor, 1/4W, 5% Carbon, 470Ω	Allen-Bradley	CB4715	942-204-71	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
R24, 27, 34, 55, 58, 62, 128	Resistor, 1/4W, 5% Carbon, 1K	Allen-Bradley	CB1025	942-201-02	7		
R57	Resistor, 1/4W, 5% Carbon, 1.2K	Allen-Bradley	CB1225	942-201-22	1		
R22	Resistor, 1/4W, 5% Carbon, 1.5K	Allen-Bradley	CB1525	942-201-52	1		
R20, 44, 66	Resistor, 1/4W, 5% Carbon, 2.2K	Allen-Bradley	CB2225	942-202-22	4		
R15	Resistor, 1/4W, 5% Carbon, 3.3K	Allen-Bradley	CB3325	942-203-32	1		
R56	Resistor, 1/4W, 5% Carbon, 6.2K	Allen-Bradley	CB6225	942-206-22	1		
R17, 60, 109, 113	Resistor, 1/4W, 5% Carbon, 4.7K	Allen-Bradley	CB4725	942-204-72	4		
R26, 32, 54, 67, 69, 72, 74, 77, 111, 112, 129	Resistor, 1/4W, 5% Carbon, 10K	Allen-Bradley	CB1035	942-201-03	11		
R31, 35, 104, 105	Resistor, 1/4W, 5% Carbon, 12K	Allen-Bradley	CB1235	942-201-23	4		
R18	Resistor, 1/4W, 5% Carbon, 15K	Allen-Bradley	CB1535	942-201-53	1		
R9, 10, 21, 23, 50, 52, 75	Resistor, 1/4W, 5% Carbon, 22K	Allen-Bradley	CB2235	942-202-23	6		
R33	Resistor, 1/4W, 5% Carbon, 39K	Allen-Bradley	CB3935	942-203-93	2		
R43, 47, 53, 59, 65, 102, 103	Resistor, 1/4W, 5% Carbon, 47K	Allen-Bradley	CB4735	942-204-73	7		
R125, 28	Resistor, 1/4W, 5% Carbon, 68K	Allen-Bradley	CB6835	942-206-83	2		

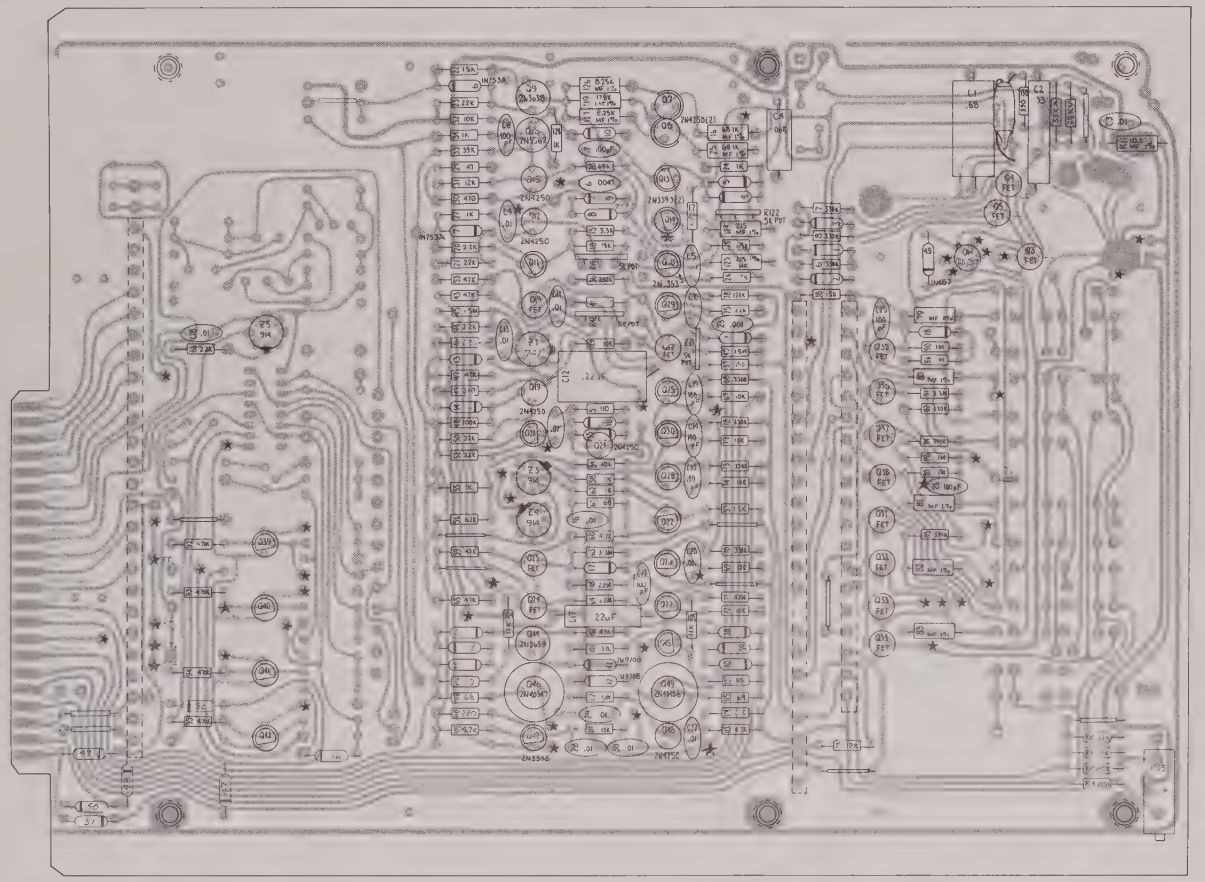
Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
R48	Resistor, 1/4W, 5% Carbon, 100K	Allen-Bradley	CB1045	942-201-04	1		
	Resistor, 1/4W, 5% Carbon, 1 Meg	Allen-Bradley	CB1055	942-201-05	1		
R12, 14, 64, 118	Resistor, 1/4W, 5% Carbon, 220K	Allen-Bradley	CB2245	942-202-24	4		
R6-8, 36, 68, 70, 73, 78, 85	Resistor, 1/4W, 5% Carbon, 330K	Allen-Bradley	CB3345	942-203-34	9		
R84	Resistor, 1/4W, 5% Carbon, 390K	Allen-Bradley	CB3945	942-203-94	1		
R71	Resistor, 1/4W, 5% Carbon, 470K	Allen-Bradley	CB4745	942-204-74	5		
R40, 45	Resistor, 1/4W, 5% Carbon, 1.5M	Allen-Bradley	CB1555	942-201-55	2		
R63	Resistor, 1/4W, 5% Carbon, 3.3M	Allen-Bradley	CB3355	942-203-35	2		
	Thermal Link	Wakefield	259.1	992-010-01	1		
	Heatsink	Thermalloy	2211B	991-001-01	2		
	Transipad	Thermalloy	7717-3N	992-010-50	2		
CR45	Diode, IN457	Continental Devices	IN457	961-045-70	1		
R46	Resistor, 1/4W, 5% Carbon, 220Ω	Allen-Bradley	CB2215	942-202-21	2		
DS-1	Indicator, Neon	General Electric	NE-ZE	968-010-03	1		
C1	Capacitor, .68 mfd, Polycarb	Elpac	B5A684	911-036-84	1		
	Pins, mating	Elco	02-060-114-6200	973-080-01	65		
	Standoff, 1/4 x 7/16	Amatom	9531-C-A-0440	991-020-01	3		
	Standoff, 1/4 x 1/8	Amatom	9536-C-A-0440	991-020-02	6		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	T3 Program Card Assembly	Doric	100-469-02	100-469-02	1		
	Circuit Board	Doric	100-235-04	100-235-04	1		
	Resistors:						
	1% Metal Film, 1K	Corning	RN60D Series	920-310-01	1*		
	1% Metal Film, 68.1K	Corning	RN60D Series	920-368-12	1*		
	1% Metal Film, 100K	Corning	RN60D Series	920-310-03	1*		
	5% Carbon, 1/4W, 22K	Allen-Bradley	CB2235	942-202-23	5*		
	5% Carbon, 1/4W, 100K	Allen-Bradley	CB1045	942-201-04	17*		
	Variable, 1K	Beckman	79PR1K	960-011-02	1*		
	Capacitors:						
	220 pf, Disc	RMC	JL 220X5F	901-012-21	11*		
	Diodes:						
	IN914	Continental Devices	IN914	961-091-40	14*		
	IN914	Continental Devices	IN914	961-091-40	**		

* Quantity shown is for T3 operation; quantity doubles for T3D requirement

** Quantity will be between 45/60 dependent upon segment selection.

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	T3 Chassis						
	Front Panel	Doric	100-257-02	100-257-02	1		
	Insert Panel	Doric	100-268-02	100-268-02	1		
	Excitation Transformer	_	_	100-702-00	1		
	Transformer Mounting Bracket	Doric	100-267-00	100-267-00	1		
	Connector, 2 Pin	Winchester	JF-2S-2P-AB	973-020-01	2		
	Rear Bezel Assembly	Doric	100-465-06	100-465-06	1		
	Connector	Amphenol	57-40140	973-100-02	1		
	Binding Post, Black	Pomona Elect	2382-0	973-300-01	2		
	Binding Post, Red	Pomona Elect	2382-2	973-300-02	2 2		
	Binding Post, White	Pomona Elect	2382-9	973-300-03	2		
	Binding Post, Blue	Pomona Elect	2382-6	973-300-04	1		



ASSEMBLY NOTES

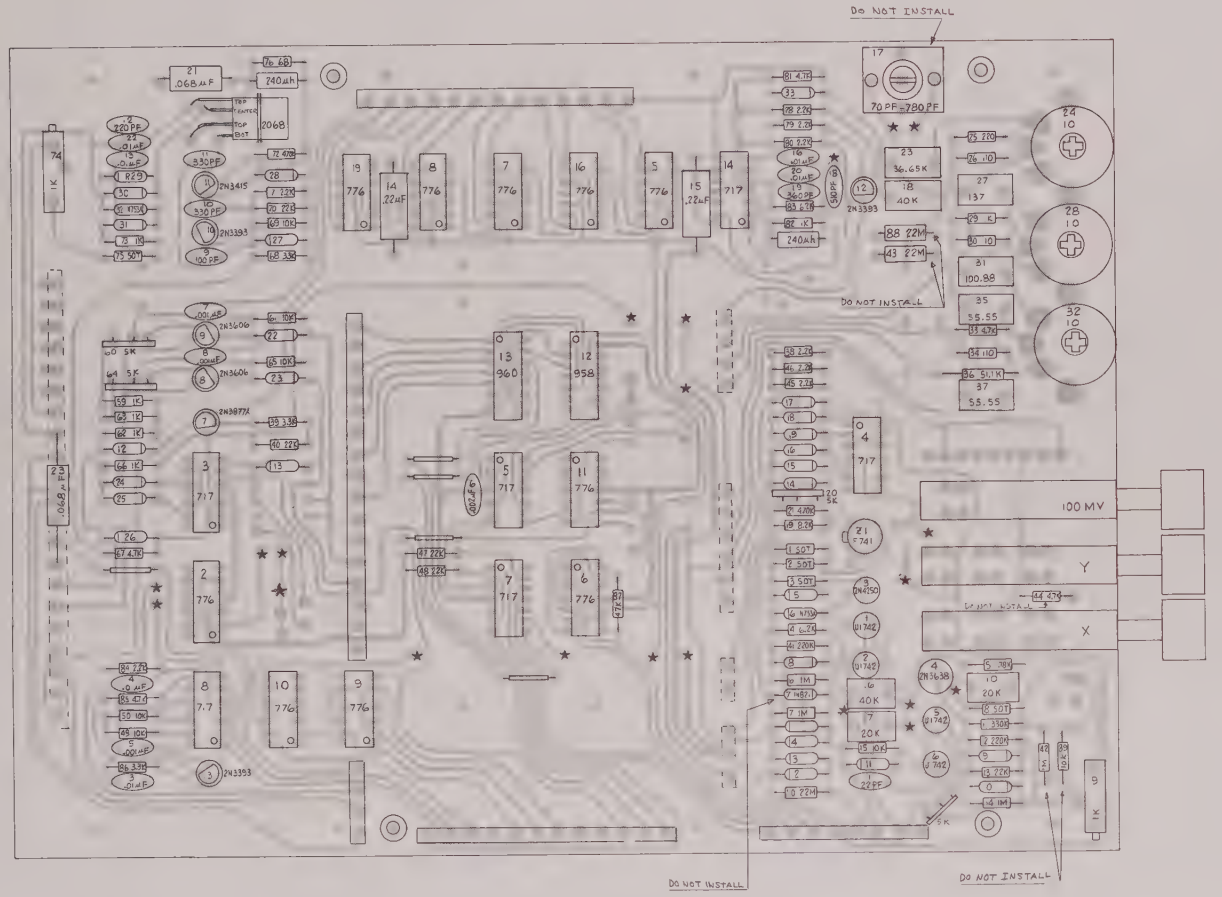
DES.	T_	T3
R9	NOT INSTALLED	INSTALLED
R10	"	"
R11	"	"
R13	"	"
R14	"	"
R41	2.4 MEG.	619 K
R79	51.1 K	39.2 K
R80	68.1 OHMS	133 OHMS
R81	113 OHMS	56.2 OHMS
R84	56.2 OHMS	113 OHMS
R85	56.2 OHMS	56.2 OHMS
Q35	NOT INSTALLED	INSTALLED
Q36	"	"
Q37	"	"
Q38	"	"

	°C	°F	.1°	1	2	3	4
Fy	CR50	CR51	CR47				
Fx	CR48	CR49	CR52				
DEC ONLY				FT1	FT2	FT3	FT4

NOTES: UNLESS OTHERWISE SPECIFIED.

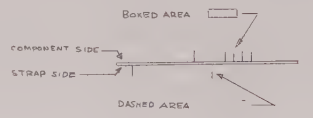
1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL FETS ARE U1742.
3. ALL DIODES ARE IN914
4. ALL UNMARKED TRANSISTORS ARE 2N3877A.
5. DASH AREAS INDICATES ELCO PINS MOUNTED ON NEAR SIDE.
6. ★ INDICATES FEED-THRUS. (44)

DORIC SCIENTIFIC		ANALOG ASSEMBLY T 5F	
TOLERANCE UNLESS NOTED		MATERIAL NOTED	
DRAWN DYNA PAC BC 4-16-69		FIN	
CHECK		DSC	SCALE 2 TO 1
DESIGN		MFG ASST	TYPE ASSEMBLY
RELEASE			SHT 1 OF 1
APPROVALS	DATE		DWG NO 100-425 REV 07



NOTES: UNLESS OTHERWISE SPECIFIED

1. RESISTORS ARE 1/4W 5%
2. ★ INDICATES FEEDTHRU
3. ⊙—⊙ INDICATES JUMPER
4. FOR SCHEMATIC SEE DWG # 100-252
5. INSTALL ELCO PINS AS DRAWING BELOW. LEAVE PLASTIC ON ELCO PINS.



6. ALL PARTS MUST BE MOUNTED SO MAXIMUM HEIGHT ABOVE THE BOARD IS 3/8".
7. SOLDER PADS ON TOP OF BOARD BEFORE INSTALLING C14 & C15.

QTY. REQ'D PER BACK KIT	SCHEM. REF DESIGNATOR	NOMENC. STORE OR DISTR. DIVISION	PART OR IDENTIFYING NO.	CODE IDENT. OF MANUFACTURER	ZONE	ITEM NO.
	PARTS LIST					

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± DECIMALS ± ANGLES ±

MATERIAL

FINISH

DRAWN DYN-A-PAC 7-23-8

CHECKED

APPROVED

RELEASED

DESIGN ACTIVITY APPROVAL

TITLE

DORIC

T3 MOTHER BOARD

SIZE	CODE IDENT. NO.	DRAWING NO.	REV.
D		100-052	04

SCALE 2:1 SHEET 1 OF 1

REAR PANEL CONNECTORS

SEGMENT COUNTER

SEGMENT DECODER

FOR 10 MV
REF: R37 = 1.02K
R24, R27 62Ω
R31 = 225
& R34 SHORTED
USED ONLY IN
TYPE 1400 "F"

INSTALL
R42 243 KΩ

UP SCALE BREAK DETECT		
DOWNSCALE BREAK DETECT		
NO BREAK DETECT		

	FELL THRU AN A/D LIMIT
	D, F, G, b + POL
	D, F, G, J, K & E
	E, H, 2, J, K

Y ENABLE (NEG TRUE)

X ENABLE (NEG TRUE)

Q40 BASE Q41 BASE Q42 BASE

400KHz

780Hz

50KHz

3.12KHz

1.25KHz

625Hz

312.5Hz

156.25Hz

78.125Hz

50Hz

100KHz

200KHz

400KHz

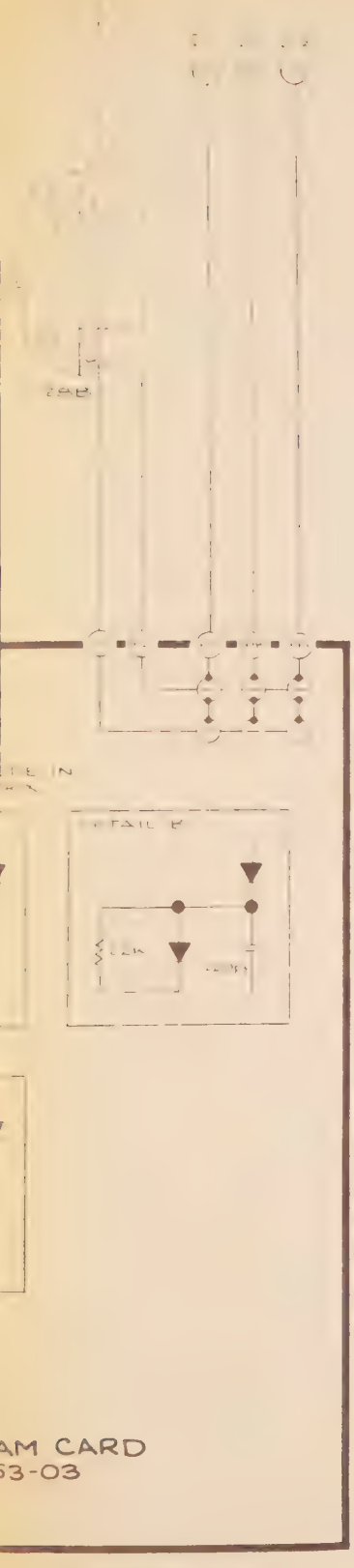
TYPICAL DI
DIODE MA

DETAIL A

DETAIL 'C

PROGR
100-2

RETURN



AM CARD
53-03

REFERENCE DESIGNATORS		
REF DESIG.	LAST USED	DELETED (NOT TO BE REUSED)
R (RES)	R111	22,21,9
C (CAP)	C24	2
CR (DIODE)	CR33	
Z (INT CKT)	Z15	
Q (XSISTOR)	Q13	

NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS IN OHMS, 1/4 W ± 5% CARBON
2. CAPACITORS IN Mf
3. ◯ INDICATES ELCO CONNECTION
4. ◯ INDICATES JACK
5. ⊣⊢ FEEDTHRU
6. O- - - O INDICATES JUMPER

REV	DESCRIPTION	DATE	DRAFT	APPV

DORIC

TITLE: T3 MOTHER BOARD

TOLERANCE AND NOTES UNLESS NOTED
FRAC ± 1/32
DEC ± .010
ANGULAR ± 1/2°
REMOVE ALL BURRS AND SHARP EDGES

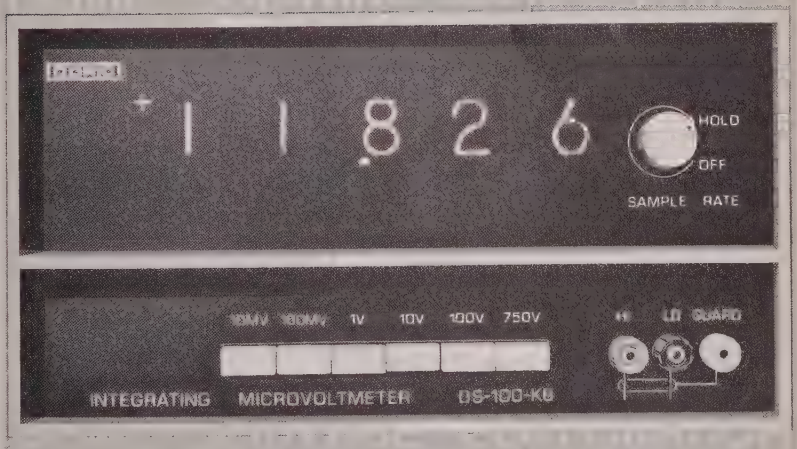
MATERIAL —
FINISH —
TOOL —
SCALE —
NEXT ASSY —
TYPE SCHEMATIC
DWG NO. 100-6[illegible]2
REV 06

DRAFT CNA PAC 4.70
CHECK
DESIGN
RELEASE
APPROVALS DATE

SHT 1 OF 1

INTEGRATING DIGITAL MICROVOLTMETER

WITH TRANSDUCER CONDITIONING FOR PHYSICAL AND SCIENTIFIC MEASUREMENT



OWNER'S MANUAL

DORIC SCIENTIFIC CORPORATION

7969 ENGINEER ROAD • SAN DIEGO, CALIFORNIA 92111 • TELEPHONE 714/277-8421

DORIC SCIENTIFIC CORPORATION REPRESENTATIVES

( ) ANDERSON ELECTRONICS
30785 Grand River Avenue
Farmington, Michigan 48024
(313) 476-9161

( ) APPLIED MEASUREMENTS, INC.
2531 Whitney Avenue
Hamden, Connecticut 06518
(203) 288-5288

( ) APPLIED MEASUREMENTS, INC.
86 Hayward Road
Acton, Massachusetts 01720
(167) 263-2766

( ) BEACON
2285 Peachtree Road N.E.
Atlanta, Georgia 30303
(404) 351-3654

( ) BEACON
P. O. Box 10212
Fort Lauderdale, Florida 33305
(305) 564-4298

( ) BEACON
Huntsville, Alabama
(205) 881-5031

( ) BEACON
P. O. Box 503
Jamestown, North Carolina 27282
(919) 454-1010

( ) BEACON
P. O. Box 1278
Maitland, Florida 32751
(305) 647-3498

( ) BRETT ASSOCIATES, INC.
2705 California Avenue, S.W.
Seattle, Washington 98116
(206) 935-8054

(X) DIVERSIFIED DEVICES
P. O. Box 241
King of Prussia, Pennsylvania 19406
(215) 265-7925

( ) ENSCO
1026 3rd Avenue, S.E.
Cedar Rapids, Iowa 52403
(319) 366-1591

( ) ENSCO
7924A State Line
Prairie Village, Kansas 66208
(913) 649-4000

( ) ENSCO
6717 Vernon Avenue
St. Louis, Missouri 63130
(314) 726-2233

( ) HANSEN ASSOCIATES
P. O. Box 339
Ridgewood, New Jersey 07451
(201) 652-7055

( ) HILLEARY ASSOCIATES
2552 Ridge Road
Littleton, Colorado 80120
(303) 794-4279

( ) HILLEARY ASSOCIATES
311 Washington S.E.
Albuquerque, New Mexico 87108
(505) 265-7631

( ) HILLEARY ASSOCIATES
8888 Dyer, Suite 516
El Paso, Texas 79904
(915) 751-5491

( ) INSTRUMENTATION SYSTEMS, INC.
3481 Office Park Drive
Dayton, Ohio 45439
(513) 293-8095

( ) INSTRUMENTATION SYSTEMS, INC.
21877 Euclid Avenue
Cleveland, Ohio 44117
(216) 486-0782

( ) JAY STONE & ASSOCIATES
330 Second Street
Los Altos, California 94022
(415) 948-4563

( ) MEGATEK, INCORPORATED
1915 North Harlem Avenue
Chicago, Illinois 60635
(312) 889-1277

( ) MEGATEK, INCORPORATED
Route 1
Freetown, Indiana 47235
(317) 988-7002

( ) POWELL-PENDERGRAPH, INC.
7979 Old Georgetown Road
Washington, D.C. 20014
(301) 656-4535

( ) PRODUCT DATA COMPANY
3760 Orange Avenue
Long Beach, California 90807
(213) 595-1777

( ) SESCO
P. O. Box 9448
Austin, Texas 78758
(512) 476-6835

( ) SESCO
P. O. Box 31357
Dallas, Texas 75231
(214) 231-8981

( ) SESCO
P. O. Box 36844
Houston, Texas 77036
(713) 782-6837

( ) Please contact us directly
DORIC SCIENTIFIC CORPORATION
7969 Engineer Road
San Diego, California 92111
(714) 277-8421 CALL COLLECT

DORIC SCIENTIFIC CORPORATION

7969 ENGINEER ROAD • SAN DIEGO, CALIFORNIA 92111 • TELEPHONE 714/277-8421

TWO YEAR WARRANTY

Doric Scientific Corporation hereby warrants each instrument of its manufacture as follows:

1. At the time of delivery of each instrument to the original purchaser, Doric Scientific Corp. UNCONDITIONALLY WARRANTS that it shall be free from defects in parts, materials and workmanship; and

2. Commencing with the date of shipment of each instrument to the original purchaser, and for a period expiring TWO YEARS from said date, Doric Scientific Corp. UNCONDITIONALLY WARRANTS that each unit shall remain free from defects in parts, materials and workmanship.

In the event any instrument fails to meet the terms of this warranty, Doric Scientific Corp. agrees to provide corrective action. Refer to the Owner's manual for the proper procedure.

The warranties herein shall not obligate Doric Scientific Corp. in any manner whatsoever with respect to, and shall not be applicable to, any defects which after an inspection by Doric Scientific Corp. are not to Doric Scientific Corp.'s reasonable satisfaction demonstrably the result of defective parts, materials or workmanship. We are not liable for consequential damages.

CERTIFICATION

Doric Scientific certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when shipped from the factory. Doric Scientific further certifies that its calibration measurements are traceable to NBS.

DORIC SCIENTIFIC CORPORATION

7969 ENGINEER ROAD • SAN DIEGO, CALIFORNIA 92111 • TELEPHONE 714/277-8421

QUICK REACTION SERVICE

DORIC is organized to provide maximum up-time to all customers who have invested in DORIC instruments. The repair procedure we strongly recommend will get you "back on-the-air" faster than you could expect from any other type of service.

1. IMMEDIATELY on identification of some type of problem, refer to your Owner's Manual, Troubleshooting section. Review the section briefly to try to ascertain what corrective measures you may be able to perform with minimum effort.

2. Telephone the local sales representative of Doric. Their telephone number should be stamped on the front page of the original manual. Otherwise, check the appropriate sections of the EEM or EBG for a current listing. Advise the sales representative or his secretary that you are having problems. Give them the following information:

Your name
Company Name & Division
Area Code, Telephone, Extension
City and State
Complete Model Number (take from rear panel tag)
Serial Number and Shipping date (rear panel)

Our representatives have been instructed to wire or TWX this information to us immediately on receipt of your telephone message. Note: If you cannot easily locate our current representative, give us a collect call, identify yourself through the operator and hold for three minutes while we locate your contract files.

3. Within a few working hours of your initial call to our representative, and within minutes after our receipt of your distress signal, we will be calling you directly to troubleshoot the instrument by telephone. The modular construction together with the simplicity of design allows extreme ease of telephone isolation to a particular problem.

4. On identification of the problem, we will immediately act to ship the replacement part(s) or board to your home address by air mail. We can ship directly to your company address, if desired. However, this frequently requires more formal paperwork for both parties as well as inserting substantial time delays due to your receiving department, etc. Additionally, a small part has a high probability of getting lost in a large company or government agency.

We are generally willing to accept your word that any necessary purchase orders to cover the replacement parts will be issued through the normal and slower channels. Be assured that we want to help you solve the problem.

5, In rare instances, or should you prefer it, we may suggest that you return the instrument to DORIC for servicing. In these cases, please refer to the packing and shipping instructions in the manual. Failure to pack it properly can cause damage not covered by the warranty.

6. Turn-around time on factory repairs will rarely exceed two (2) days.

JET-PART

Rapid service and minimum down-time is dependent on the availability of spare parts. Your investment in a DORIC meter deserves fast parts service.

Inventories

Doric Scientific maintains an adequate inventory of spare and replacement parts of all standard instruments. Spare plug-in boards are stocked.

Parts Identification

As mentioned elsewhere, every DORIC Owner's Manual has a complete parts list. Each part is cross-correlated with the schematic reference to make it simple to determine which parts you want to order. For each part, the DORIC part number will be provided as well as the original manufacturer's number. Additionally, approximate prices are listed to simplify order placement.

Lead Time

Better than 90% of all orders for replacement parts received by DORIC will be shipped the same day. For routine parts requisitions for stocking purposes, as opposed to repair, please indicate your desired delivery.

Ordering Procedure

When ordering a replacement part or supply item, please specify:

1. the DORIC stock number for the part, and
2. its complete name as identified in the parts list, and
3. the model number and serial number of the instrument which these parts are intended for

TABLE OF CONTENTS

Paragraph		Page
	SECTION I - DESCRIPTION & OPERATION	
1-1	Introduction	1-1
1-2	DS-100 Mainframe, Description	1-2
1-3	Plug-In Facilities and Measurement Modules — Description and Operation	1-4
	SECTION II - UNPACKING, INSTALLATION, REPACKING AND CONNECTING UP	
2-1	General	2-1
2-2	Receiving Inspection	2-1
2-3	Installation	2-1
2-4	Repacking Instructions, Original Container	2-6
2-5	Input Connectors - Voltage Measurements	2-10
2-6	Connections for Minimizing Common Mode Noise Interference	2-10
2-7	Connections when using Digital Output Device	2-12
2-8	External Connections when using S3-1 and S4-1	2-16
2-9	External Connections when using P Options with S4-2	2-17
	SECTION III - SPECIFICATIONS	
3-1	DC Voltmeter Specifications	3-1
3-2	DC/DC Ratiometer Specifications	3-3
3-3	High Speed Measurement Specifications	3-3
3-4	Specifications for I/O Units S3-1, S4-1 and S4-2	3-4
3-5	General Specifications	3-5
	SECTION IV - THEORY OF OPERATION	
4-1	Introduction	4-1
4-2	System Theory	4-3
4-3	Circuit Description	4-6
4-4	Digital Circuits	4-7
4-5	Power Supplies	4-14
4-6	Analog Circuits	4-14
4-7	Self-Check Switch, Option B	4-21
4-8	High Speed, Option E	4-21
4-9	I/O Boards S3-1, S4-1, S4-2	4-22

TABLE OF CONTENTS (continued)

Paragraph		Page
	SECTION V - CALIBRATION	
5-1	General	5-1
5-2	Calibration Procedures	5-1
5-3	Equipment Required - All K Series & P Series Plug-Ins	5-2
5-4	Calibration of Single-Range Plug-Ins	5-2
5-5	Calibration of Multi-Range Plug-Ins	5-3
5-6	Calibration of Ratio Ranges	5-4
	SECTION VI - TROUBLESHOOTING	
6-1	Introduction	6-1
6-2	Notes on Circuit Analysis	6-1
6-3	Troubleshooting Programs	6-1
6-4	Pin Chart	6-8
6-5	Normal Power Supply Voltages and Load Resistances	6-9
6-6	Hold Condition Checkout Chart	6-9
	SECTION VII - PARTS LISTS AND SCHEMATICS	
7-1	Introduction	7-1
7-2	Basic DS-100 Parts List	7-3
7-3	Individual Parts - K and P Series	7-17
7-4	Options	7-29

LIST OF ILLUSTRATIONS

Figure No.	Title	Page
1.1	DS-100 K6 Automatic Integrating Microvoltmeter	1-1
1.2	Principal Components of Doric DS-100 Series	1-3
1.3	DS-100 with S3-1 and S4-1 Systems Application	1-11
1.4	Electronic Switches - Outputs	1-12
2.1	Line Voltage Setting	2-2
2.2	Detail of Latch, Stand and Shipping Screws	2-3
2.3	Rack Mount Option W - One DS-100 Mounted	2-4
2.4	Rack Mount Option W - Two DS-100 Mounted	2-5
2.5	Repacking Instructions - Original Container	2-7
2.6	Construction of Shipping Case	2-8
2.7	Guarding Techniques - Configuration I	2-11
2.8	Guarding Techniques - Configuration III	2-13
2.9	Connection to Digital Output Device, Showing Common Mode Path	2-14
3.1	Outline Dimensions of Voltmeter	3-6
4.1	Simplified Diagram of Analog Circuits	4-2
4.2	Dual Slope Timing Diagram	4-2
4.3	Timing Diagram	4-4
4.4	CμL923 J-K Flip Flop	4-7
4.5	CμL914 Dual 2 Input Gate	4-8
4.6	CμL958 Decade Counter	4-9
4.7	CμL959 Storage Register	4-10
4.7A	CμL960 Decoder/Driver	4-10
4.8	Analog Switching Channel	4-16
4.9	Solid State Guard Crossing Block Diagram	4-23
5.1	Internal Calibration Panel	5-1

SECTION I

DESCRIPTION & OPERATION

1-1. INTRODUCTION

This manual provides full operational and service data for the Doric DS-100 K and P Series of Automatic Integrating Digital Microvoltmeters. Each of the precision test instruments in the series consists of a basic DS-100 Mainframe, into which is inserted the appropriate plug-in measurement module. As shown in Figures 1.1 and 1.2, the readout is incorporated in the mainframe, while the measurement function and range controls are located in the plug-in unit.

DS-100 INTEGRATING MICROVOLTMETER fig 1.1

Once the basic DS-100 mainframe has been purchased, any type K or P measurement module can be inserted into it to provide numerous measurement capabilities. Further, a number of options, some of which are themselves plug-in circuit boards, are used to extend the capabilities of the instrument. The resulting model numbers reflect the options and plug-ins chosen.

Types K and P, covered by this manual, offer precision multirange DC Voltage and DC/DC Ratio measurements over a dynamic range from the microvolt level to ±750VDC.

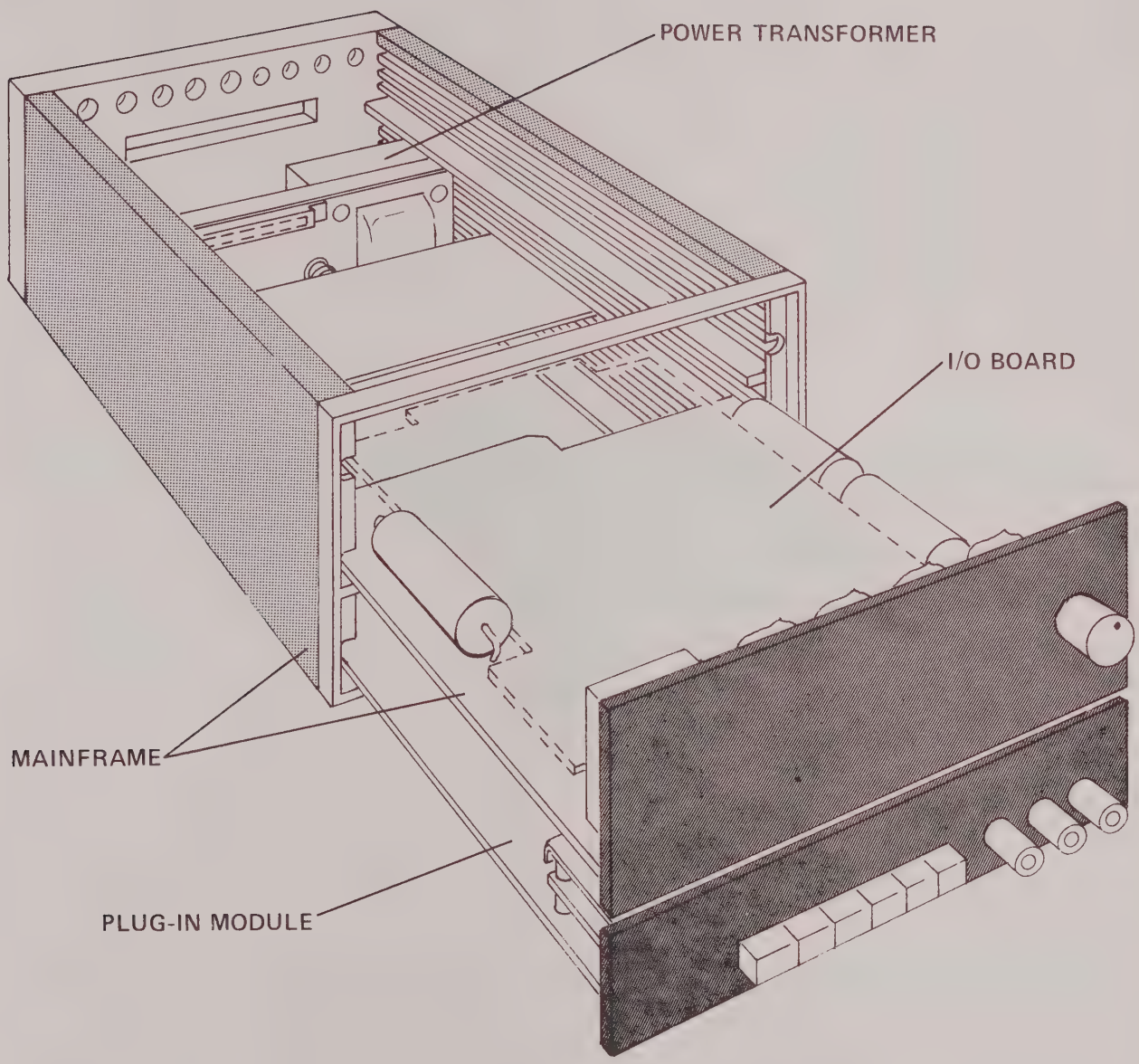
Other models in the Doric series are Type T3, specially designed for direct temperature measurements from thermocouples, and Type T2 for strain gage transducer measurements.

Separate manuals are devoted to the T Series, which include the necessary signal conditioning to enable the direct readout in engineering units of weight, force, microstrain, psi, degrees of temperature, etc.

Doric instruments combine their revolutionary AUTO-ZERO circuitry with a novel dual-slope integration technique to provide remarkable low level millivolt measurement accuracies and freedom from zero drift. All input circuits in all modules are fully floating, guarded and differential, so that true signal measurements can be made in grounded or ungrounded test configurations and in the presence of severe ground loops, recirculating currents and other sources of common mode interference.

1-2. DS-100 MAINFRAME, DESCRIPTION

The DS-100 mainframe carries the digital readout, the functional indicators, and the manual sample rate and power control. The mainframe is designed so that any of the Type K and P modules will plug into it. High-intensity Burroughs Nixie Tubes forming the in-line readout provide a sharp display of the measurement digits and decimal points; associated storage circuits hold the display constant during and between encodings. There is no blanking, blurring or last-digit flutter. The display storage feature permits visual tracking of the incremental digital changes in the value of a varying signal. An "S" symbol flashes with each new encoding to confirm that the voltmeter is sampling, even though the input signal and the digital indication may remain constant. An automatic "OL" overload symbol is displayed whenever the input exceeds the range or overrange limits of the meter; "R" symbol indicates ratio mode in operation; "MV" indicates that meter is displaying millivolts; "+" and "-" indicate the signal polarity. Automatic overranging extends the measurement capability to 120% of nominal full scale on the 10 millivolt through 100 volt ranges. The overrange "1" is a neon lamp.



PRINCIPAL COMPONENTS OF DORIC DS-100 SERIES fig 1.2

1-2-1. DS-100 MAINFRAME, OPERATION

The only control on the mainframe is a power switch S1 and SAMPLE RATE adjustment R6, operated by a single knob. Power is removed when the control is set fully counter-clockwise to OFF. Power is applied and the voltmeter starts encoding at the maximum sample rate when the control is moved clockwise from the OFF position. The sample rate decreases as the control is moved further clockwise. In the HOLD position (extreme clockwise) the voltmeter stores the reading indefinitely. When using the I/O boards the control should be set to HOLD, so that the voltmeter only responds to external sample commands.

1-3. PLUG-IN FACILITIES AND MEASUREMENT MODULES — DESCRIPTION AND OPERATION

Numerous fully-interchangeable plug-in modules can be used with the DS-100, as shown in the accompanying list, and described more fully below. These provide several alternative ranging combinations; an optional self-checking feature; DC/DC Ratio capability with unipolar variable reference; high speed and remotely-controlled interface operation and remote closure BCD data outputs for systems use. All Doric instruments are available either in rack mounting or bench mounting versions. A conveniently-located latch beneath the front bezel releases the plug-in module, allowing it to move freely outwards for calibration, adjustments, self-check, etc. without turning off the power.

1-3-1. MODELS K1, K2, K3 AND K4 PLUG-IN MODULES

Inserting Model K1, K2, K3 and K4 Plug-in accessory modules into the mainframe provides the instrument with the following single DC ranges:

Model	Range FS	Overranges to
K1	±10.000 millivolts	±12.000 millivolts
K2	±100.00 millivolts	±120.00 millivolts
K3	±1.0000 volts	±1.2000 volts
K4	±10.000 volts	±12.000 volts

PLUG-IN MEASUREMENT MODULES AND OPTIONS

Description	Model Numbers	
Single Range DVM 10 MV Full Scale	K1	Plug-In Modules
Single Range DVM 100MV Full Scale	K2	
Single Range DVM 1V Full Scale	K3	
Single Range DVM 10V Full Scale	K4	
Four Range DVM 10MV through 10V	K5	
Four Range DVM 1V through 750V	K5A	
Six Range DVM 10MV through 750V	K6	
Four Range Programmable DVM 1V through 750V	P1	
Six Range Programmable DVM 10MV through 750V	P2	
Four Range Autoranging DVM 1V through 750V	P1A	
Six Range Autoranging DVM 10MV through 750V	P2A	
Autorange Board	A	Options and Accessories
Self-Check	B	
DC/DC Ratios	C	
High Speed (20 readings per second)	E	
BCD Outputs (solid state closures)	S3-1	
BCD Outputs & Remote Program (solid state closures)	S4-1	
Remote Programming	S4-2	
Rack Mounting Adapter (with filler panel)	W	
Extender Board	X	
Rear Signal Inputs	Y	
Special Low Thermal Signal Input Cord Set	Z	

No range selector buttons are provided. A standard input lead is plugged into the front-panel banana jacks for signal "HI", signal "LO", and "GUARD", and the instrument is switched on. If option "C" is used to measure DC/DC Ratios with K1 through K4 plug-ins, the units function as single-range ratiometers only; they provide a single ratio range the same as the voltage range in the original instrument, but will not measure voltages as well as ratios.

1-3-2. MODEL K5 PLUG-IN MODULE

Inserting Model K5 plug-in accessory module into the mainframe provides the instrument with four discrete DC ranges, having full scale of ±10.000 millivolts, ±100.00 millivolts, ±1.0000 volt, and ±10.000 volts respectively. The meter will overrange to 120% F.S. on all ranges. Four interlocking push buttons are used to select the range required. If two or more buttons are pressed simultaneously no damage will result, but readings will be incorrect. When all buttons are released, the 10 volt range is automatically selected and the "OL" overload symbol flashes to indicate improper operation. Table below shows the attenuator settings, reference outputs, etc., which automatically come into operation as each range is selected.

RANGE CHART

RANGE	FULL SCALE INPUT VOLTS	ATTENUATOR SETTING	REFERENCE OUTPUT	A1 GAIN	BCD RANGE		
					$R2^2$	$R2^1$	$R2^0$
1	1000V (750V Max)	x.01	10V	1.1	0	0	1
2	100V	x.01	1V	11	0	1	0
3	10V	x1	10V	1.1	0	1	1
4	1V	x1	1V	11	1	0	0
5	.1V	x1	.1V	110	1	0	1
6	.01V	x1	.01V	1,100	1	1	0

By itself, Model K5 is self-encoding and is entirely manually operated; however, if option S3-1 (see below) is included, the meter may be remotely encoded by means of a suitable external command as described in the specifications for option S3-1.

Option C, added to a K5 plug-in, provides the same number of DC/DC Ratio ranges as are present in the K module, but will not measure voltages as well as ratios.

1-3-3. MODELS K5A AND K6 PLUG-IN MODULES

Inserting Models K5A and K6 plug-in accessory modules into the mainframe provides the instrument with the following multiple DC measurement ranges:

Model	Ranges F.S.	Overranges to
K5A	±1.0000 volt ±10.000 volts ±100.00 volts ±750.00 volts	±1.2000 volts ±12.000 volts ±120.00 volts no overrange
K6	±10.000 millivolts ±100.00 millivolts ±1.0000 volt ±10.000 volts ±100.00 volts ±750.00 volts	±12.000 millivolts ±120.00 millivolts ±1.2000 volts ±12.000 volts ±120.00 volts no overrange

Otherwise Models K5A and K6 are identical to Model K5 described above.

1-3-4. MODELS P1 AND P2 PLUG-IN MODULES

Inserting Models P1 and P2 plug-in accessory modules into the mainframe provides the instrument with the following DC measurement ranges:

Model	Ranges F.S.	Overranges to
P1	±1.0000 volt ±10.000 volts ±100.00 volts ±750.00 volts	±1.2000 volts ±12.000 volts ±120.00 volts no overrange

Model	Ranges F.S.	Overranges to
P2	±10,000 millivolts	±12.000 millivolts
	±100.00 millivolts	±120.00 millivolts
	±1.0000 volt	±1.2000 volts
	±10.000 volts	±12.000 volts
	±100.00 volts	±120.00 volts
	±750.00 volts	no overrange

All of the ranges shown above are manually selectable by means of the panel-mounted pushbuttons, and also can be remotely selected by means of suitable external commands when the input/output option S4-1 is used. Specifications for range selection commands will be found under S4-1 option. Connector pin designations are included in Section II, Paragraph 2-9.

Both P1 and P2 have a manual switch to select function whenever the ratio option "C" is included. The function selector is a good-quality slide switch mounted on the top of the inside panel of the plug-in. With option "C", Models P1 and P2 function as voltmeters or ratiometers, according to the setting of the manual function selector switch. Except for the number of available ranges, options P1 and P2 are identical in design and operation.

If it is expected that the instrument will later be remotely programmed, P1 or P2 should be installed initially.

1-3-5. MODEL P1A AND P2A PLUG-IN MODULES

Models P1A and P2A will provide the same facilities as P1 and P2, but in addition, they will accept the factory-installed Autorange Board, option A. P1A and P2A are fitted with an additional "AUTORANGE" pushbutton which when pressed, places the instrument into the fully autoranging mode. If it is expected that the instrument will later be remotely programmed, or will require autorange, P1A or P2A should be installed initially.

1-3-5-1. MODEL A AUTORANGE BOARD

Model A Autorange board is a factory-installed option for use with Models P1A and P2A. It provides full autoranging on all of the meter's measurement ranges.

1-3-6. MODEL B — SELF CHECK OPTION

Model B Self Check option provides a self check of the voltmeter by causing it to measure the voltage of the internal reference. A calibration log of such checks is recorded on the calibration panel decal. When the button, located on the calibration panel, is pressed, the voltage indicated by the meter should be within 1 digit of the recorded value, showing that all elements of the meter are functioning correctly. If a discrepancy greater than 1 digit occurs, meter requires calibration. (See Section V on calibration.)

1-3-7. MODEL C — DC/DC RATIO MODE OPTION

The DC/DC Ratio option can be used with either Type K or P, but when used with Type K, the combination instrument functions as a ratiometer only, without voltage measurement ranges. When used with multiple-range Models, such as K5 or P1, the Model C provides as many ratio ranges as there are voltage ranges. When used with Models P1 or P2, the function selector switch will select voltage measurements or ratio measurements. Normal input connections for ratio measurements are the same as for the DC voltage measurements but with the addition of a BLUE banana jack on the rear panel to accept an additional cable carrying the POSITIVE reference input voltage. An outstanding feature of the Model C is its ability to measure widely different ratios using a reference voltage from 8 to 12 volts without losing its ±.01% resolution. The function selector switch is located on the top of the inside panel of the plug-in module.

Standard C option is a 3-wire device; signal low and reference low terminals being common. If the polarity of the signal changes with respect to the reference, indicated polarity of the signal also changes. THE DECIMAL POINT IS PLACED SO THAT THE READING EQUALS THE RATIO TIMES TEN. The following ratio chart shows the ratio ranges available.

1-3-8. MODEL E — HIGH SPEED OPTION (DATA SYSTEM VERSION)

Inclusion of this option increases the encoding speed of the instrument to 50 milliseconds while maintaining accuracy within ±.01% of standard instrument specifications. The

RATIO CHART

Ratio Range	DC Range	Ratio Readings*	Actual Ratios
0.001:1	10MV	MV ±0.000 to MV ±12.000	±0.0000000:1 to ±0.0012000:1
0.01:1	100MV	MV ±00.00 to MV ±120.00	±0.000000:1 to ±0.012000:1
0.1:1	1V	±.0000 to ±1.2000	±0.00000:1 to ±0.12000:1
1:1	10V	±0.000 to ±12.000	±0.0000:1 to ±1.2000:1
10:1	100V	±00.00 to ±120.00	±0.000:1 to ±12.000:1
100:1	750V	±000.0 to ±750.0	±00.00:1 to ±75.00:1

*The ratio symbol "R" is displayed with each reading.

response time includes all delays to be expected in a typical data system, and allows external encoding of the meter at up to 20 readings per second. Built-in data storage register effectively doubles the overall system rates by permitting time-sharing.

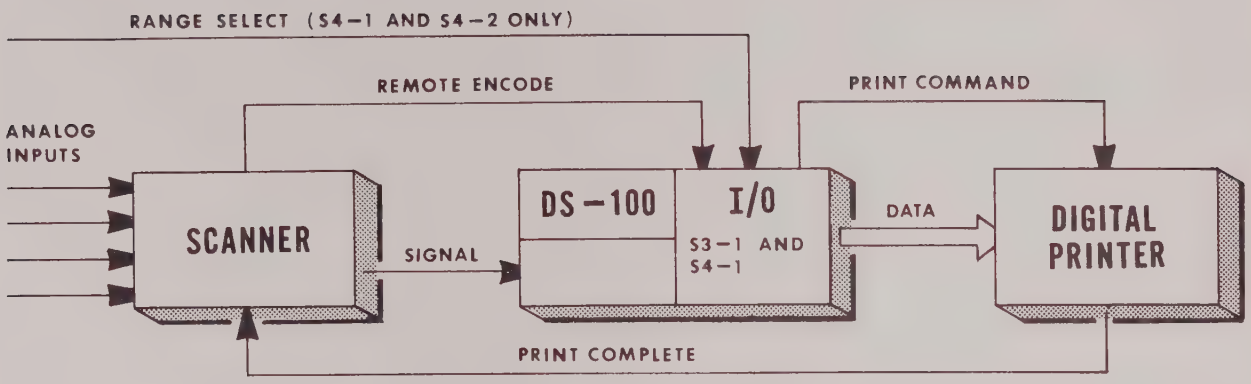
1-3-9. MODELS S3-1, S4-1 and S4-2 INPUT/OUTPUT INTERFACE CARDS

Models S3-1 and S4-1 are input/output modules which enable the Doric DS-100 Series to interface with and be controlled by external logic elements. They each consist of a plug-in card, as shown in Figure 1-2, with the necessary connectors for logic inputs and outputs, and transistor switches for operating printers, etc.

Model S4-2 has no electrical data outputs, but allows the meter to be programmed remotely from a suitable external source. Inputs consist of programming commands which place the meter into the required range, and of encode commands which remotely encode the meter. Pin connections are shown in Section II Paragraph 2-8. When using any of the Input/Output modules, the SAMPLE RATE control on the mainframe is set to HOLD, enabling the meter to respond to remote encode commands only.

1-3-9-1. ELECTRICAL INPUTS

Adding S3-1, S4-1 and S4-2 to the DS-100 allows the meter to accept AC-coupled remote encode commands from an external source. With S4-1 and S4-2 there is the extra capability of accepting remote positive true range select commands in the form of voltage levels. A positive true logic level may be applied to one of six range lines. The range number indicates the number of places to the left the decimal point is to be placed.



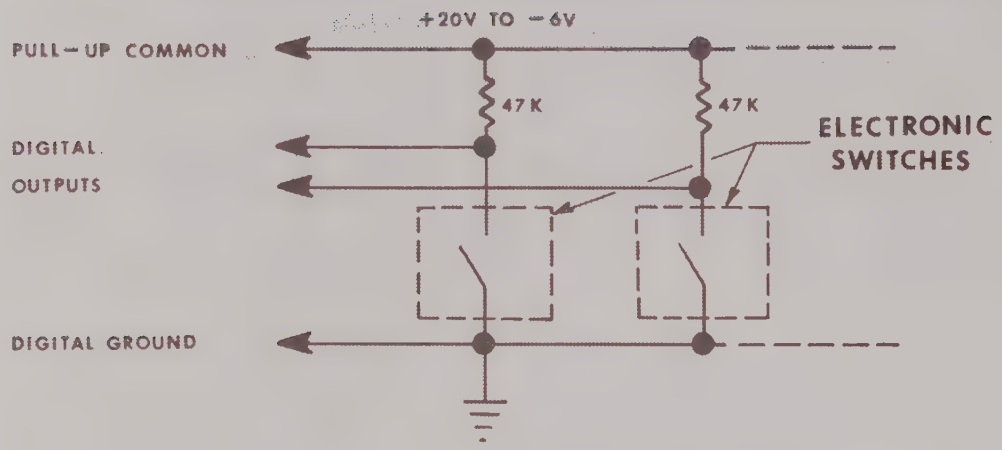
DS-100 WITH S3-1 AND S4-1 SYSTEMS APPLICATION fig. 1.3

Range 1 is the 750.0V Range, Range 2 is the 100.00V Range, etc. The false level is from -20V to +.5V. The true level is +4V to +20V. The input impedance is 100K or greater. Overvoltage protection to ±100V is provided. The input logic levels may normally be controlled by logic types which have 4V or greater output swing, such as DTL and TTL integrated circuits.

1-3-9-2 ELECTRICAL OUTPUTS

By using the S3-1 or S4-1, the digital readout of the meter is converted into 8-4-2-1 "closure false" digital data outputs.

The DS-100 Microvoltmeter uses a unique solid state closure output system shown in Figure 1.4. The magnitude, polarity and range of the measurement are represented by 23 bits of information. Each of these bits is available at the rear connector J6, in the form of an electronic switch closure to digital ground. All the switch closures are connected to a common pull-up line by 47K pull-up resistors. This pull-up common is available on J6, Pin X. By applying a voltage between -6V and +20V to this line, the closures may be converted to any desired voltage levels. All information is presented in the 8-4-2-1 BCD format and is available in closure false (standard) or closure true (optional). The electronic switches are essentially pure resistors when "on" with a resistance less than 200Ω for load currents up to ±2 MA. The "off" resistance is greater than 100 megohms.



ELECTRONIC SWITCHES − OUTPUTS fig 1.4

The output circuits are also compatible with the 830 or 930 Series DTL I. C. logic and type SN5400, SN7400 or 9000 Series TTL logic or other logics having less than 2. 0MA input "0" load current. For use with I. C. logic, the pull up common is tied to the +5V I. C. supply.

The complete isolation of the electrical outputs from the meter circuitry ensures that the overall common mode rejection ratio is maintained in spite of a common mode voltage on the signal lines of 30V peak-to-peak. For input connections, refer to Section II. Specifications of the commands and data logic levels are included in the specifications section.

For external connections to S3-1, S4-1 and S4-2, refer to Section II Paragraph 2-8 and 2-9. For connections when using a digital output device, refer to Section II Paragraph 2-7. Schematic No. 100-636 shows the circuit arrangement of the I/O Board using "closure true" outputs, and is complete with pin connections and component designators.

1-3-10. MODEL W. RACK MOUNTING ADAPTER

The rack mounting adapter accepts one voltmeter and a filler panel or two voltmeters. It has mounting ears, and can be mounted in a standard 19" rack, as illustrated. For assembly details refer to Section II.

1-3-11. MODEL X. EXTENDER BOARD

This extender board enables either the mainframe or the plug-in module to be operated at some distance forward from their normal positions, thus facilitating service.

1-3-12. MODEL Y. REAR SIGNAL INPUTS

Inclusion of this option provides a duplicate set of signal input plugs on the rear rail. These are in parallel with the input plugs on the front panel, and are used to convey the signal to the meter when operating in a system rack.

1-3-13. MODEL Z. LOW THERMAL INPUT CORD SET

Special soldering techniques render this input lead less susceptible to thermoelectric effects, and permit more accurate measurement of low level inputs.

SECTION II

UNPACKING, INSTALLATION, REPACKING AND CONNECTING UP

2-1. GENERAL

Retain all packing materials in case the instrument must be returned to Doric; repacking instructions are also provided in this section.

2-2. RECEIVING INSPECTION

The unopened package should be checked for external damage before it is accepted from the shipping agency. After unpacking, the instrument should be carefully checked for damage, which should be reported to the shipping agency and to Doric.

NOTE

For shipping purposes, the plug-in module is held firmly in place by two shipping screws, Phillips-head 4-40 x 1/2", located just forward of the front feet. These screws should be removed on arrival, and replaced before reshipment (see Figure 2.2).

2-3. INSTALLATION

2-3-1. POWER REQUIREMENTS AND LINE VOLTAGE SETTING

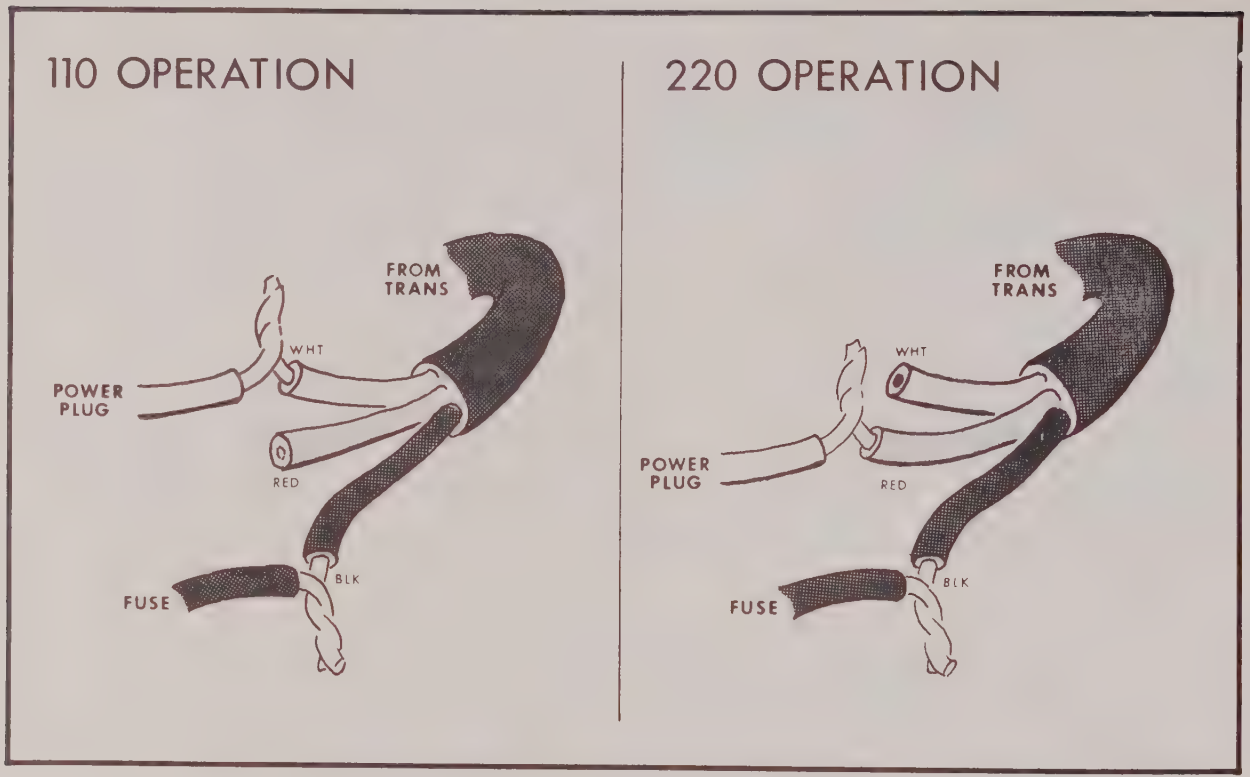
The instrument is normally wired to operate from a 115 volt ±10% AC power source, 50 to 400 Hz, but can also be wired to operate from a 230 volt ±10% AC power source. A .25A slo-blo power fuse is used for 115 volts; a .125A for 230 volts. To change from 115 volts to 230 volts (refer to Figure 2.1):

a. Remove the four screws holding rear panel, slide the top panel out from the rear.

b. Remove the black insulation from the junction of the power cable and the power transformer cable.

c. Break connection between white power wire and white transformer wire, and solder white power wire to previously unused red transformer wire.

d. Re-insulate wires and reassemble the instrument.



LINE VOLTAGE SETTING fig 2.1

2-3-2. BENCH MOUNT INSTRUMENTS

Bench mount instruments have four rubber feet. A folding stand is attached between the two front feet. With stand folded, the instrument lies flat on the work bench. When stand is pulled down, the front of the instrument is raised for easy viewing (Figure 2.2).

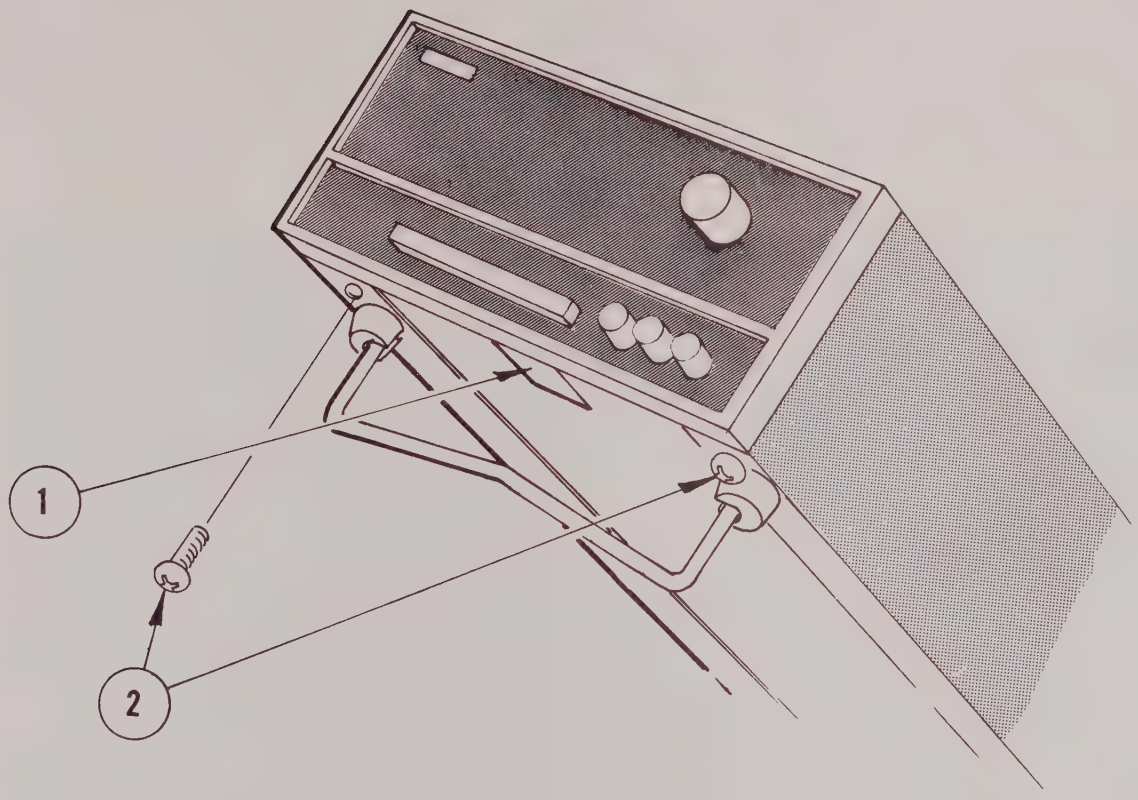
2-3-3. RACK MOUNTING ADAPTER

Option W converts bench mount instruments to rack mount instruments. A filler panel is provided for the vacant space if one voltmeter is installed (Figure 2.3); or two instruments can be mounted side by side, (Figure 2.4). The rack adapter is shipped separate from the basic meter.

To mount instrument in Rack Mounting Adapter:

a. Remove the four feet and folding stand from the bench instrument.

b. Four screws provided are inserted through holes in the front and rear mounting bars and into the holes previously used to secure the four feet. (Do not use the screws that held the feet.)

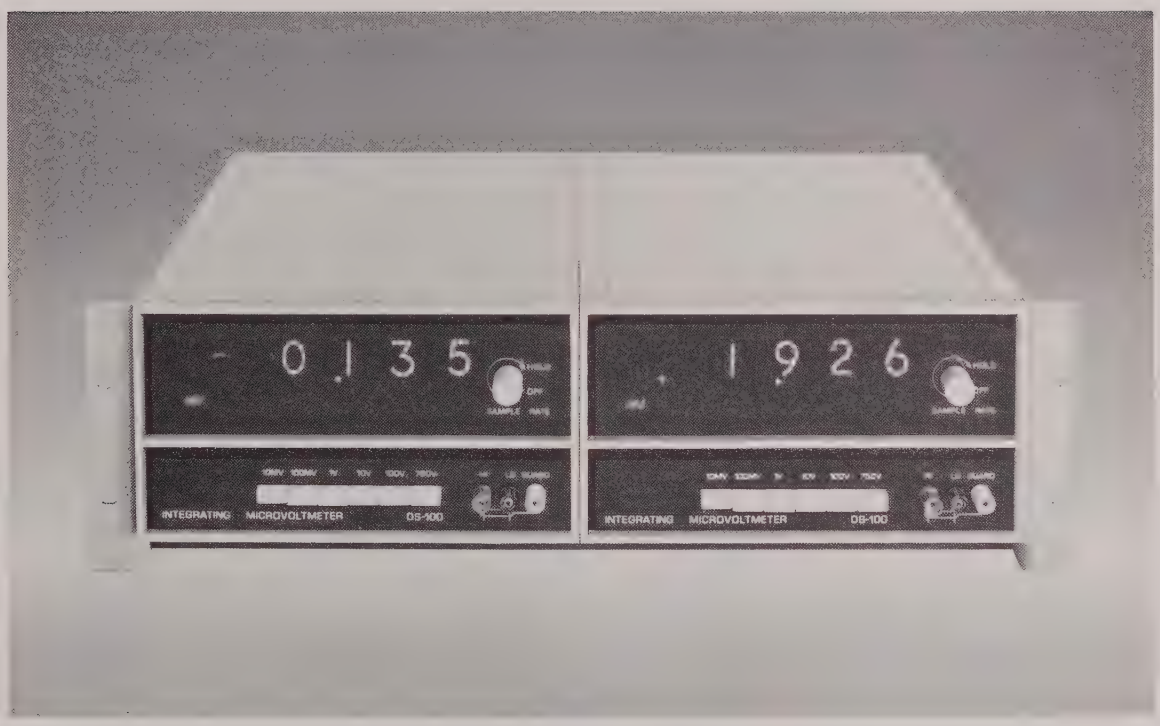


1. LATCH

2. SHIPPING SCREWS

DETAIL OF LATCH, STAND & SHIPPING SCREWS fig 2.2

RACK MOUNT OPTION W - ONE DS-100 MOUNTED fig 2.3



RACK MOUNT OPTION W - TWO DS-100 MOUNTED fig 2.4

c. Use four screws from the adapter kit to secure the filler panel to the front mounting bar.

d. Four screws are used to mount the adapter in a standard 19" equipment rack.

2-4. REPACKING INSTRUCTIONS, ORIGINAL CONTAINER

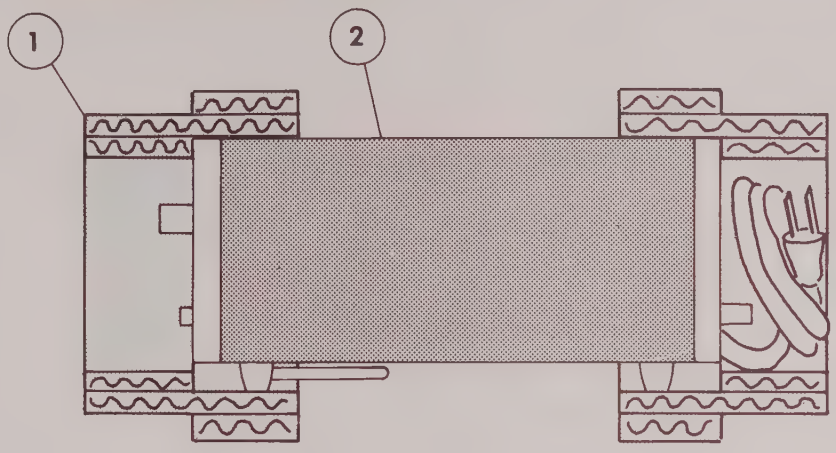
If an instrument must be returned to Doric for any reason, return must be authorized and instrument must be packaged with great care to ensure safe arrival. Procedure is to telephone or write Doric Scientific Corporation requesting authorization to return the instrument to the factory. Ask Doric to send a special shipping carton free of charge if you do not have the carton in which the unit was originally shipped. When authorization is received, pack the instrument in the Doric container as follows (see Figure 2.5):

a. Ensure that the plug-in module is firmly seated and held in place by the spring-latch, then install the two shipping screws, 4-40 x 1/2", in the holes forward of the front feet (Figure 2.2). UNLESS BOTH SHIPPING SCREWS ARE IN PLACE, DAMAGE TO THE INSTRUMENT WILL RESULT.

b. Attach a tag bearing your name, telephone number and extension, indicating the services or repairs needed, or symptoms noted. If out of warranty, enclose a purchase order for required services or repairs needed, or request estimate.

c. Use tape to secure the rectangular cardboard collars around both ends of the instrument; ensure that the collars are fitted around the feet, and protect the panel controls with padding. Place about one inch of padding and a sheet of cardboard at the closed end of the original container and then insert the instrument into the container. Add a sheet of cardboard and sufficient padding at the open end of the container to prevent any movement of the instrument. Seal the open end of your carton with strong shipping tape.

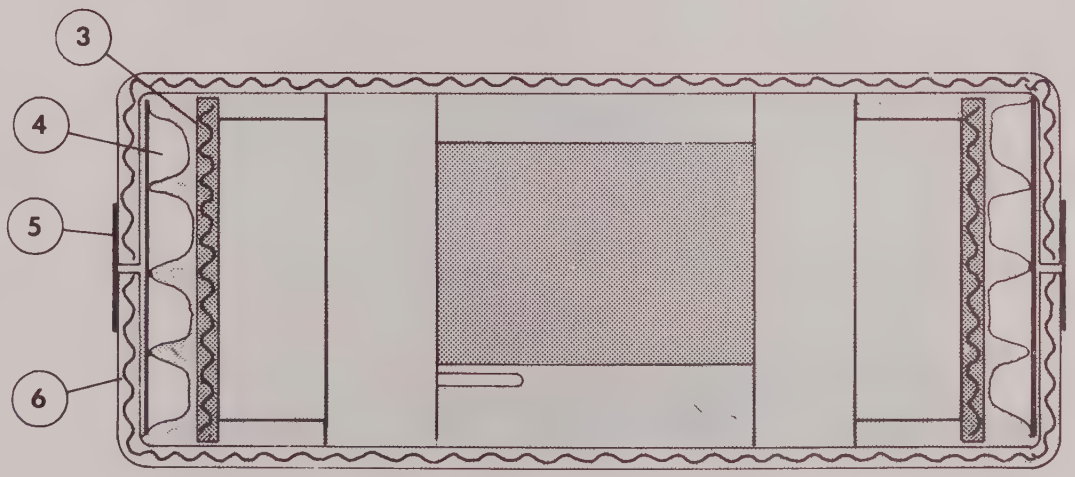
d. Mark the container with your name, and address, and "FRAGILE, DELICATE, INSTRUMENT". Identify the instrument by model and serial number in any



STEP 1

FOR DETAILED INSTRUCTIONS, SEE PARAGRAPH 2-4.

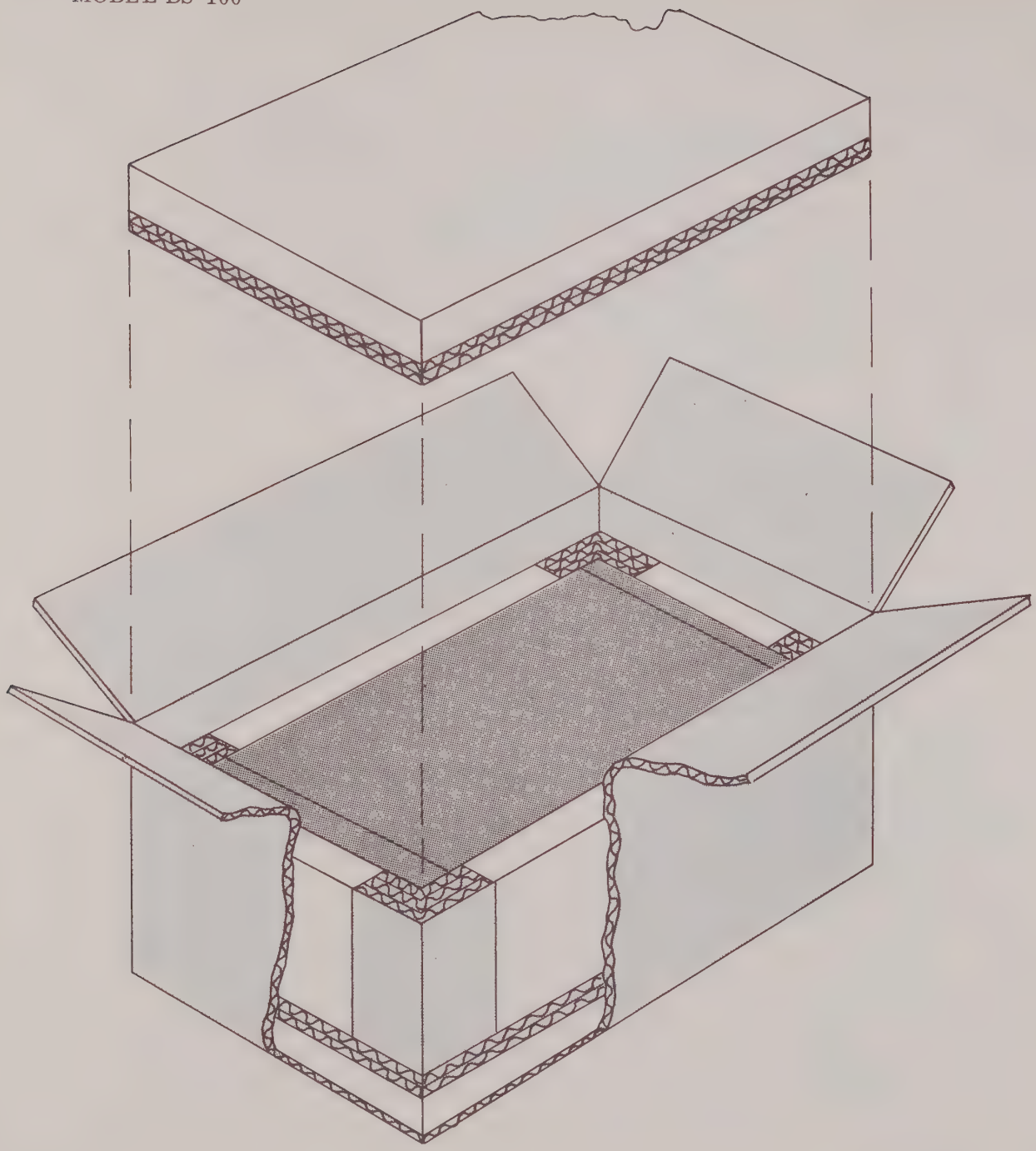
Place rectangular cardboard collars (1) around both ends of the instrument (2), coil power cord as shown above.



STEP 2

Place about 1" of padding (4) and a sheet of cardboard (3) at closed end of container (6). Insert instrument (with collars attached), place second sheet of cardboard at open end of container, add padding, close and seal carton with strong shipping tape (5).

REPACKING INSTRUCTIONS ORIGINAL CONTAINER fig 2.5



If original Doric container is not available, construct and use the shipping case shown above. For detailed instructions of construction of case and packing of instrument, see paragraph 2-4-1.

CONSTRUCTION OF SHIPPING CASE fig 2.6

correspondence with Doric. Serial numbers are located on the bottom of analog plug-in and inside the Main-Frame cavity for the plug-in.

e. Ship the instrument to Doric Scientific Corporation, 7969 Engineer Road, San Diego, California 92111, --- Freight Prepaid.

2-4-1. REPACKING INSTRUCTIONS, NEW CONTAINER

If the original container is not available, and a new container must be made, proceed as follows:

a. Obtain a strong reinforced cardboard carton, of sufficient size to allow at least four inches of empty space between any part of the meter and any part of the carton. Place on bench with opening uppermost and with flaps turned back. See Figure 2.6.

b. Pack at least four inches of resilient padding (polyfoam, bubble-pack, rubberized hair) on bottom of carton, and cover with a rectangle of heavy double corrugated cardboard cut to fit the carton.

c. Wrap meter in plastic or strong paper, and place it centrally on the cardboard rectangle. Cut and insert four sets of corner pads, as shown in the illustration, sufficient to hold meter in a central position during transit. Corner pads are made of thick corrugated cardboard. Fill the four spaces between the corner pads with resilient padding.

d. Cut a second rectangle of heavy double corrugated cardboard to fit the carton and insert above meter.

e. Pack the space above the rectangle and the top of the carton with sufficient resilient padding to fill it to the top. This layer must be at least four inches thick.

f. Close flaps, seal with strong shipping tape, and reinforce all joints in carton, label and ship as outlined above.

2-5. INPUT CONNECTORS — VOLTAGE MEASUREMENTS

Signal inputs are normally led in through Hi, Lo and Guard terminal sockets mounted on the front panel of the plug-in module. Mating connectors are provided. Option No. Y provides an identical set of connectors on the rear rail of the module, in addition to the front inputs. Option Z is a low thermal effect signal input cable, four feet long which mates with the front or rear jacks and includes alligator clips on the outer end.

2-5-1. INPUT CONNECTORS — RATIO MEASUREMENT

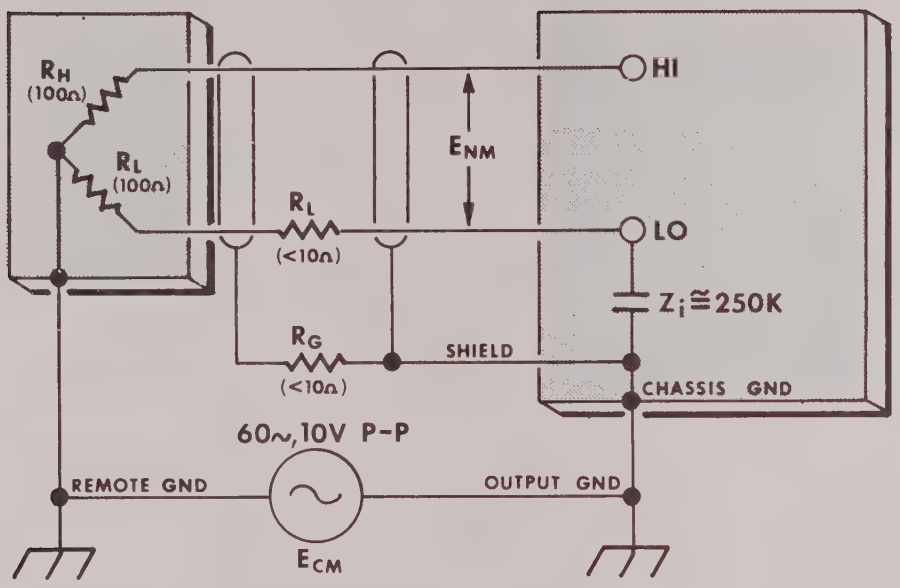
When Option C is included, an additional (blue) banana jack is provided on the rear rail for reference Hi. Signal Lo serves also as a reference Lo. Reference Hi must always be positive relative to reference Lo. The input signal may be of either polarity.

2-6. CONNECTIONS FOR MINIMIZING COMMON MODE NOISE INTERFERENCE

Guarding must be used whenever low level measurements are to be made and a significant (≥10 digits) amount of AC or DC voltage exists between the signal source and DVM chassis ground. The conditions in an unguarded system when such a common mode voltage is present are shown in configuration I, Figure 2.7. The common mode voltage, E_{cm}, causes a large current to flow through the transducer low-side resistance R_L, the signal LO lead resistance, R'_L, and from there through the isolation impedance Z_i to LOCAL GROUND. A voltage drop resulting from the common mode current will appear across R_L and R'_L. This voltage is in series with, and appears as part of the source voltage being measured, and could produce up to 4400 digits of noise (assuming 1μv/digit). To avoid this, one of three guarding systems may be used.

To choose the proper system, the characteristics of the transducer to be used must be considered. Some transducers must be grounded at installation site for safety or mechanical reasons, (e.g., thermocouples or strain gages bonded to a missile airframe). In this case, configuration II must be used. Note that the guarded isolation impedance, Z_{iG}, will be much higher than Z_i shown in configuration I. This is because the common mode currents are carried from remote ground by the guard, R_G, and drive the metalwork surrounding the DVM measurement section to a potential almost equalling E_{cm}.

I UNGUARDED DVM

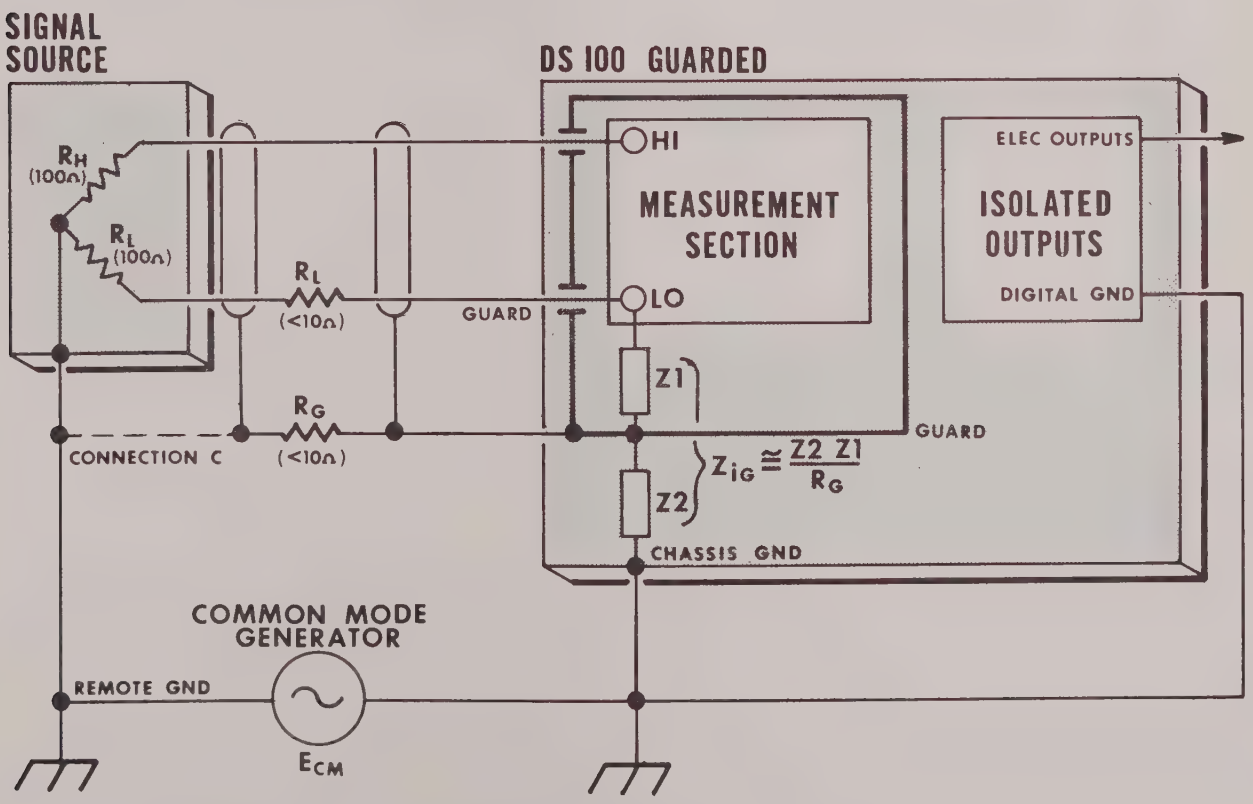


$$E_{NM} \cong \frac{E_{CM}\ R_L}{Z_i}$$

$$= \frac{10 \times 10^2}{2.5 \times 10^5} = 4 \times 10^{-3}$$

$$= 4MV\ P\text{-}P$$

II REMOTELY GROUNDED TRANSDUCER



GUARDING fig 2.7

Thus very little current flows in R_L and R'_L because the voltage drop across Z1 is very small. The key point is to make connection C at the remote site so that guard is at the remote ground potential most closely associated with the transducer being measured.

With truly floating transducers (thermocouples, batteries, etc.), Figure 2.8 configuration III may be used. It is assumed that transducer isolation impedance, Z_{ti}, is very high (higher than Z2). In this case, connection C may be made at the local (DVM) ground. This simplifies scanning systems by requiring only signal HI and LO lines to be switched rather than HI, LO and guard as in configurations II and IV. Note that guard is attached to signal LO at the remote site. The resulting CMRR will approximate that of II.

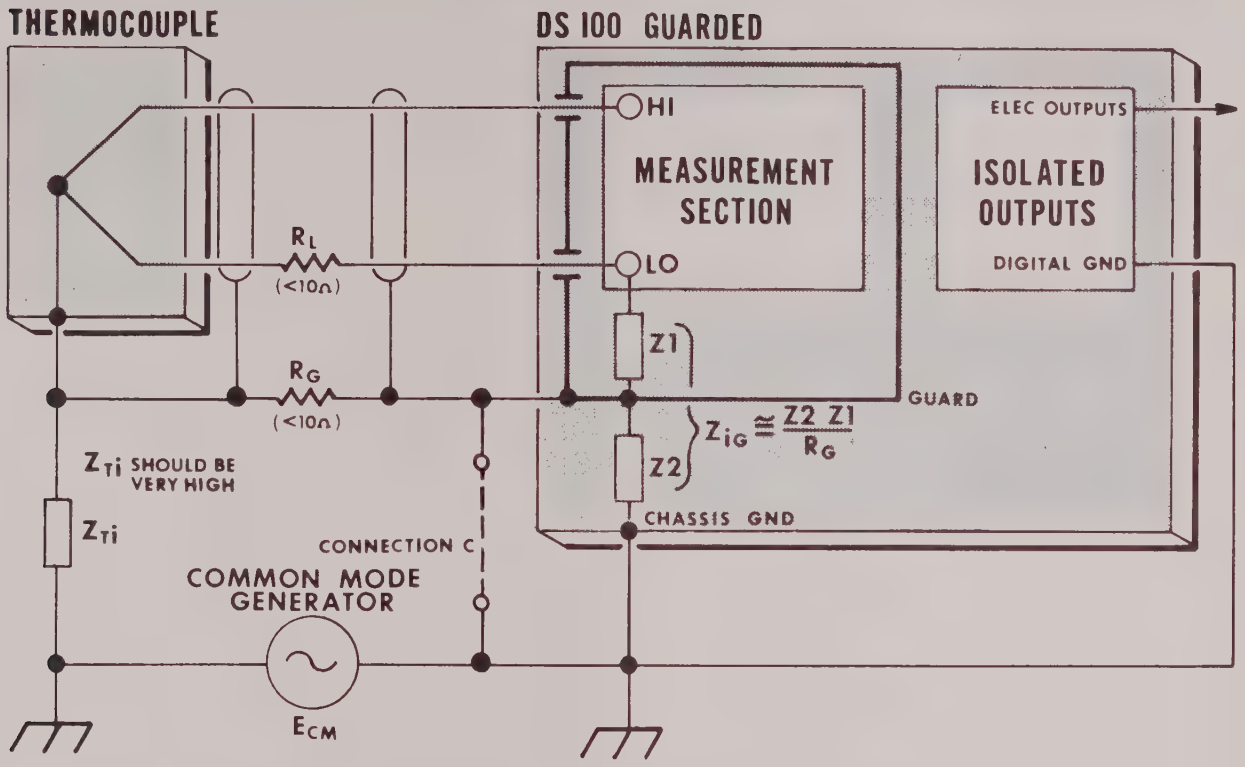
A superior technique for any kind of floating transducer is shown in Figure 2.8 configuration IV. Running an extra wire from LOCAL (DVM) ground to the low side of the remote transducer virtually shorts out the common mode source, and greatly reduces the source common mode voltage, E_{cms}. This will result in a large increase in the effective common mode rejection. When configuration IV cannot be used, quasi-floating transducers (DC power supply excited transducers, e.g., bridges, pots) generally work best with configuration II. This requires connecting one side of the power supply to remote earth ground. It should be remembered that IN ALL CASES THE TRANSDUCER OR METER MUST BE GROUNDED SOMEWHERE, BUT ONLY AT ONE POINT. A completely floating transducer-meter combination will allow uncontrolled common mode voltages to develop which are potentially dangerous and will adversely affect measurement accuracy.

For most bench applications, meters may be operated with the signal LO attached to Guard at the front panel.

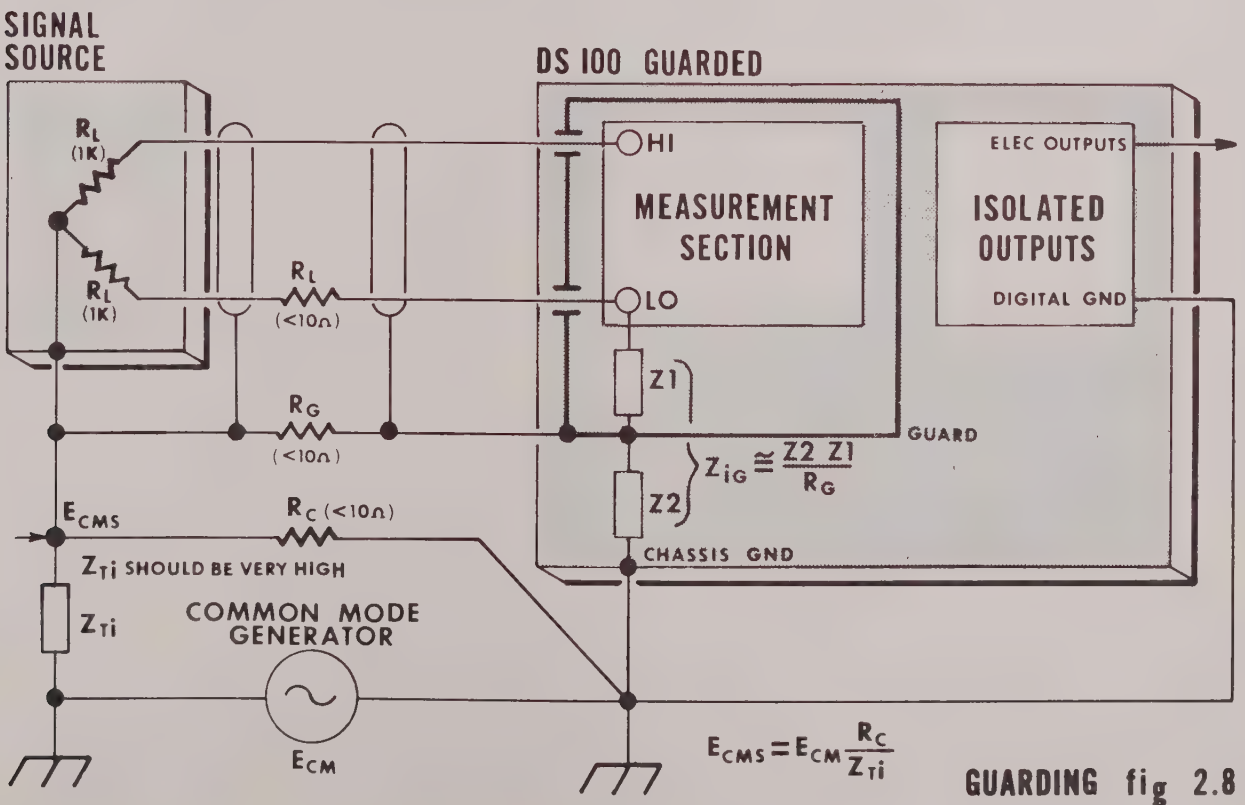
2-7. CONNECTIONS WHEN USING DIGITAL OUTPUT DEVICE

The DS-100 equipped with the S3-1, S4-1 or S4-2 I/O card will meet the stated common mode rejection ratio specifications for up to 240V p-p (±120V) common mode voltage. Overvoltage protection to 300V p-p is provided. To ensure that the common mode voltage is within the specified limits, the digital ground (J6 Pin C) should return to

III FLOATING TRANSDUCER, LOCALLY GROUNDED



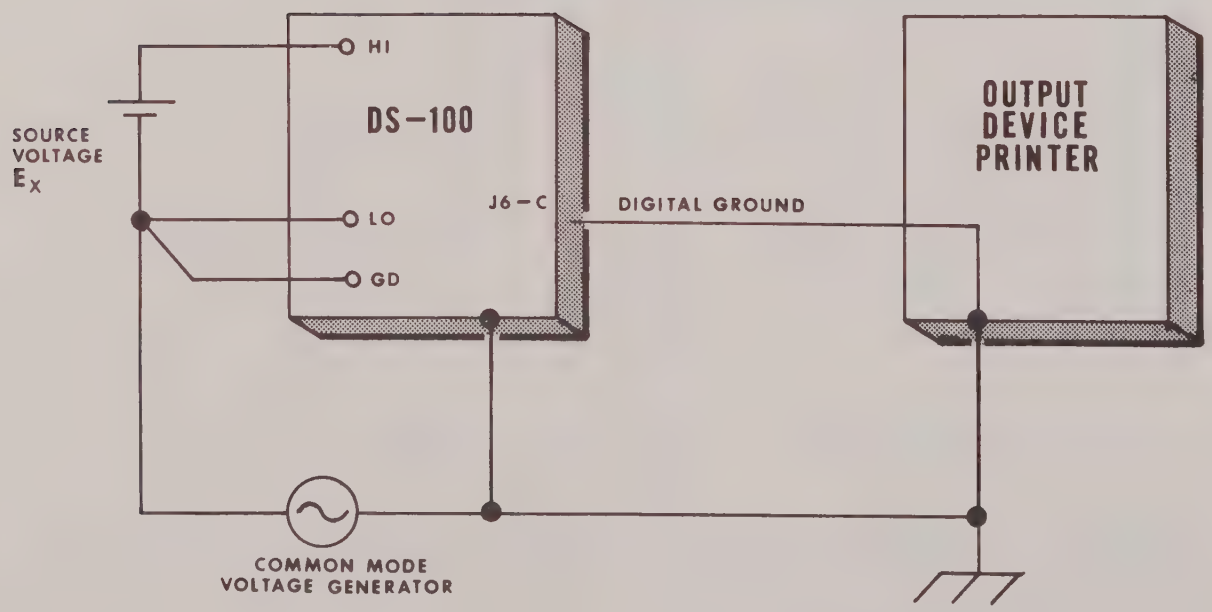
IV FLOATING TRANSDUCER, IMPROVED LOCAL GROUNDING



GUARDING fig 2.8

chassis ground when the I/O connector is used. This return path may go through the output device if desired. As shown in the discussion in Paragraph 2-6, the signal source will ultimately also return to chassis ground, either directly or through the common mode generator. See Figure 2-9.

The pin connections for mating the DS-100 to the Hewlett-Packard M59-562A or HO-59-5050B digital printer are shown in the list following. A cable made to this configuration will mate the DS-100 to either the H-P M59-562A or the H-P HO-59-5050B. These printers with the prefix numbers shown supply pull-up voltages compatible with their logic.



CONNECTION TO DIGITAL OUTPUT DEVICE, SHOWING COMMON MODE PATH fig. 2.9

PIN CONNECTIONS

DS-100 CONNECTOR J6 TOP SIDE	HO 59-5050B Conn. A1J1 or M59-562A Conn. J101	DS-100 CONNECTOR J6 BOTTOM SIDE	HO 59-5050B Conn. A1J1 or M59-562A Conn. J101
A		1	23
B	27	2	14
C	50	3	13
D	12	4	
E	37	5	11
F	36	6	
H	38	7	
J		8	9
K		9	35
L		10	34
M		11	10
N		12	21
P		13	
R		14	7
S	25	15	33
T	24	16	32
U		17	8
V		18	
W		19	
X	39	20	
Y		21	26
Z		22	5
a		23	31
b		24	30
c		25	6
d		26	1
e		27	2
f		28	3
h		29	29
j		30	28
k		31	4

2-8. EXTERNAL CONNECTIONS WHEN USING S3-1 AND S4-1.

INPUT/OUTPUT CONNECTION CHART

CONNECTOR J6 TOP SIDE	CONNECTOR J6 BOTTOM SIDE
(p) k. Range 5 select	31. 2_0
(p) j. Range 6 select	30. 4_0
(p) h. Range 4 select	29. 8_0
(p) f. Range 3 select	28. 1_0
(p) e. Range 2 select	27. Output Range 2^1
(p) d. Range 1 select	26. Output Range 2^0
c. Blank	25. 2_1
b. Function 1 select	24. 4_1
a. Function 2 select	23. 8_1
Z. Blank	22. 1_1
Y. Blank	21. Output Range 2^2
X. Pull-up Common	20. Blank
W. -24V	19. Blank
V. Blank	18. Blank
U. Blank	17. 2_2
T. LO Ref. *	16. 4_2
S. HI Ref. *	15. 8_2
R. Function 3 select	14. 1_2
P. Decimal 1 select	13. Output Function 2^1
N. Decimal 2 select	12. Pull-up Regulator Input *
M. Decimal 3 select	11. 2_3
L. Decimal 4 select	10. 4_3
K. Blank	9. 8_3
J. Blank	8. 1_3
(p) H. Digital Ground	7. Output Function 2^0
(p) F. Digital Ground	(p) 6. Sample command
(p) E. Digital Ground	5. 1_4
(p) D. Digital Ground	4. Overload
(p) C. Digital Ground	3. - polarity
(p) B. Digital Ground	2. NOT Overload *
A. Sample complete -HP Printer	(1) 1. Sample complete (print command)

NOTES:

1. The connector is Winchester PQD31SO with solder terminals.
2. The notation on the magnitude outputs are as shown:
   2_0 equals 2×10^0 equals 2; or 8_2 equals 8×10^2 equals 800.

*3. For use with HP562A or 5050A Printers.

4. For pins marked (p), see Section 2-9.

2-9. EXTERNAL CONNECTIONS WHEN USING P OPTIONS WITH S4-2

When programming options are used with S4-2, which has no electrical outputs, none of the digital data pins are connected. Only those pins marked (p) on the connection list given in paragraph 2-8 are used in this instance.

SECTION III

SPECIFICATIONS

3-1. DC VOLTMETER SPECIFICATIONS

DC Ranges: 10MV, 100MV, 1V, 10V, 100V, and 750V are standard full scale ranges available. Instrument is capable of overranging to 120% of all full scale ranges, except 750V range; accuracy specifications also apply to overrange.

Accuracy: 24 hours; +23°C ±1°C

- 10MV range: ±0.02% RDG. ±0.01% FS. ±2μV
- 100MV, 1V, and 10V ranges: ±0.01% RDG. ±0.01% FS
- 100V and 750V ranges: ±0.01% RDG. ±0.02% FS

Sensitivity and Repeatability:

Range	Sensitivity	Repeatability
10MV	1 μV	±2 μV
100MV	10 μV	±10 μV
1V	100 μV	±100 μV
10V	1MV	±1MV
100V	10MV	±10MV
750V	100MV	±100MV

Temperature Effects: +10°C to +40°C

- 10MV range: 0.005% RDG/°C ±0.5 μV/°C
- 100MV range: 0.003% RDG/°C ±0.5 μV/°C
- 1V to 750V ranges: 0.003% RDG/°C

Calibration Stability: Meter will stay within ±0.01% RDG for 30 days; ±0.03% RDG for 6 months from date of last calibration.

Auto-Zero:	Automatic zero drift correction feature applies to all measurement plug-ins.
Input Circuit:	Guarded, floating, differential input.
Input Impedance:	1000 megohms on 10MV, 100MV, 1V, and 10V ranges; 10 megohms on 100V and 750V ranges. Impedance is constant at all times, during and between encodings.
Common Mode Rejection:	120 db minimum at all frequencies with 100 ohms unbalance; effective CMR increases at 40 db/decade (12 db/octave) above 59 Hz.
Maximum Common Mode Voltage:	250 volts DC or peak AC. (Guard to Chassis)
Maximum "LO" to Guard Voltage:	50 volts DC
Normal Mode Rejection:	50 db minimum at 60 Hz (±.15%) increasing at 60 db/decade (18 db/octave) from 30 Hz on 10MV, 100MV, 1V, and 10V ranges; 45 db at 60 Hz on 100V and 750V ranges increasing at 40 db per decade. Integrator pole breaks at 3 Hz rising at 6 db per octave to 30 Hz.
Speed:	500 ms/reading (to 0.01%) all ranges, adjustable to 10 seconds/reading by panel control. See Option E for higher speeds.
Internal Reference:	Temperature compensated zener, typically 6 ppm/℃.
Overload Protection:	100V continuous on DC voltage ranges up through 10V without damage; 750V without damage on 100V and 750V ranges.
Polarity:	Automatic polarity determination, with visual and electrical outputs.

3-2. DC/DC RATIOMETER SPECIFICATIONS

These specifications apply to instruments with Option C. Type P plug-in modules with Option C are capable of providing both voltage and ratio measurements; type K plug-in modules with Option C are capable of providing only ratio measurements.

Ratio Ranges:	Signal Input:External Reference 0.001:1; 0.01:1, 0.1:1, 1:1, 10:1, and 100:1 are standard ratio ranges available that correspond to the 10MV, 100MV, 1V, 10V, 100V and 750V DC voltage ranges, respectively.
Accuracy:	±0.01% RDG. ±0.01% FS with 8 to 12 volt reference, additive to DC voltage specification accuracies.
External Reference:	Any positive DC from 8 volts through 12 volts without loss of four digit (0.01%) resolution. Higher or lower reference inputs available on order. Positive or negative DC signal inputs may be used.
Reference Input Impedance:	10 megohms or greater
Speed:	Same as DC voltmeters.

3-3. HIGH SPEED MEASUREMENT SPECIFICATIONS

These specifications apply to instruments with Option E.

Response Time:	50 ms to within 0.01%, includes all settling delays and measurement period; allows external encoding rates up to 20 readings per second; built-in storage register for time-sharing effectively doubles overall system rates attainable.

Integration Period:	16-2/3 ms, crystal controlled.
Common Mode Rejection:	Greater than 120 db at any frequency, with 100 ohms unbalance in "HI" lead.
Normal Mode Rejection:	Infinite rejection cusps at 60 Hz and multiples thereof, increasing at 20 db/decade; rejection at 60 Hz (±0.15%) is at least 50 db.
Accuracy:	Add 0.01% FS to standard specifications.
Resolution:	1 part in 12000.

3-4. SPECIFICATIONS FOR I/O UNITS S3-1, S4-1 AND S4-2

3-4-1. ELECTRICAL PROGRAM INPUTS

Sample Command:	A negative going AC coupled edge of 4V to 20V amplitude, 2 microsecond minimum fall time, 50 microseconds minimum duration; dynamic input impedance, 47KΩ. The sample command line must remain quiescent for at least 2 ms prior to negative going edge.
Range Command:	A positive true logic level may be applied to one of six range lines. The range number indicates the number of places to the left the decimal is to be located from the right side of the least significant digit. The false level is from -20V to +.5V. The true level is +4V to +20V. Input impedance is 100K or greater. Overvoltage protection to ±100V is provided.

3-4-2. ELECTRICAL OUTPUTS: CLOSURE FALSE (STANDARD)

BCD Range, Polarity, Magnitude, and Print Command:	Solid state "closure" False, 8-4-2-1 code. Closure off resistance greater than 100 megohms;

on resistance less than 200 ohms at ±2 ma. One side of each closure is on output ground. The other side is connected to a 47K resistor which is attached to a common pull-up line. Any voltage from -6V to +20V may be applied to the pull-up common pin to provide either positive or negative true voltage levels. The print command is a step equal in magnitude and polarity to the pull-up voltage with less than 2μs rise time. Note: CMRR specifications are maintained for any CMV to 24V p-p; overvoltage protection to 300V p-p is provided.

3-4-3. OPTIONS INCLUDE

S3-1, Sample Command, BCD Outputs and Print Command

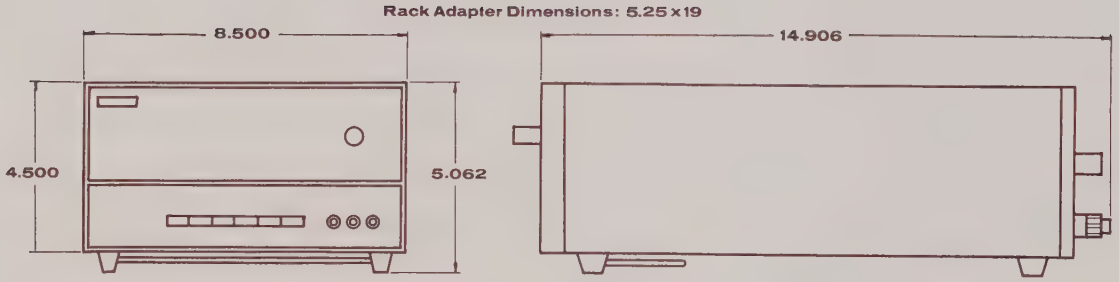
S4-1, Sample Command, BCD Outputs, Range Command, and Print Command

S4-2, Sample Command, Range Command, Print Command, NO Outputs

For pin connections, see section II, paragraphs 2-8 and 2-9.

3-5. GENERAL SPECIFICATIONS

Operating Temperature:	+10°C to +40°C (+50°F to +104°F)
Power Required:	115V ±10%, 50 Hz to 400 Hz, 20 watts maximum; 230V taps provided.
Weight:	12 lbs. net; 17 lbs shipping (approx).
Dimensions - Voltmeter:	See Figure 3-1.
Dimensions - Rack Adapter:	5-1/4" x 19" wide, accepts one or two voltmeters.



OUTLINE DIMENSIONS OF VOLTMETER fig 3.1

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION

The Model DS-100 Integrating Digital Microvoltmeter measures DC voltages by a dual-slope integration method, which is much enhanced by the introduction of the unique auto-zero feature. *

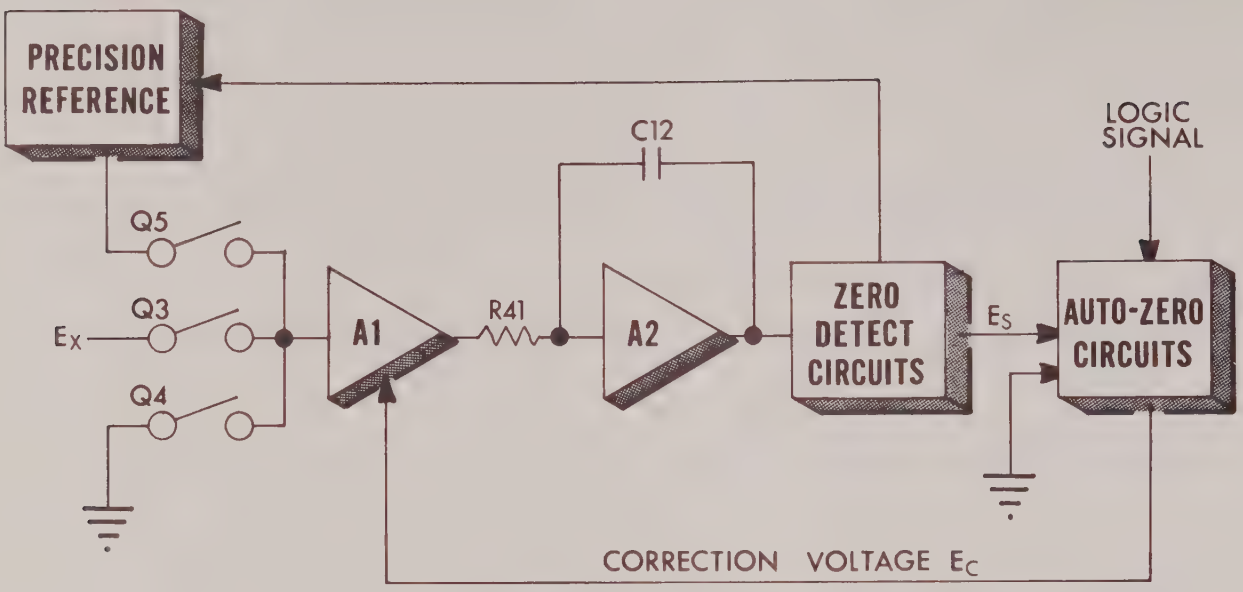
During encoding of a voltage signal, the analog input of the meter is connected to the DC signal voltage (E_X) for approximately 100 ms. During this fixed time, t_1, the integrating capacitor C12 charges at a rate proportional to the DC signal voltage. (See Figures 4.1 and 4.2.) At the end of this fixed integration time, the input of the meter is disconnected from the DC signal and is connected to a precision reference voltage with a polarity opposing that of the DC input, causing the integrating capacitor, C12 to discharge toward ground potential at a fixed rate. The discharge time t_2 required to reach ground potential is proportional both to the reference voltage and to the voltage peak, (E_P) reached by the capacitor during the fixed integration time, t_1. Figure 4.2 shows that time t_2 is directly proportional to E_X and independent of variable factors such as R41, C12 time constant, clock frequency, A1 amplifier gain, and amplifier offsets. To display E_X digitally, fixed-interval clock pulses are counted in a display counter during the discharge time t_2. The count that is accumulated is directly proportional to the input signal E_X.

4-1-1. AUTO-ZERO

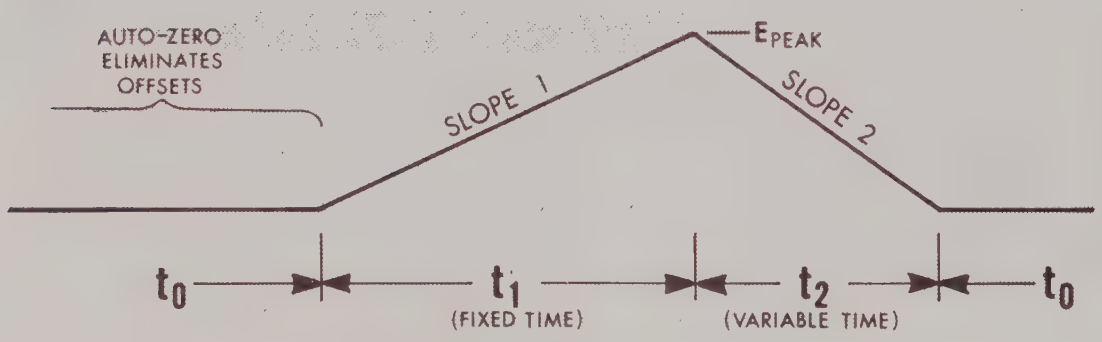
Between encodings the instrument disconnects itself from the signal input voltage E_X, and shorts its own input, (see Figure 4.1). At this time the auto-zero circuit measures the existing offset in the buffer amplifier, A1 integrator amplifier, A2, and zero crossing amplifier. At the beginning of the next encoding, the auto-zero circuit stores the required voltage to cancel the sum of the offsets in these amplifiers.

Between encodings, Q3 and Q5 are open, Q4 is closed, connecting A1's input to ground. Note that DC amplifiers A1, A2 and the zero detection circuits are in series. Any

* Patent Pending



SIMPLIFIED DIAGRAM OF ANALOG CIRCUITS fig 4.1



DUAL SLOPE TIMING DIAGRAM fig 4.2

$$\text{Volts/sec of slope 1} = \frac{E_x A_1}{R_{41} C_{12}}$$

$$\text{Volts/sec of slope 2} = \frac{E_R A_1}{R_{41} C_{12}}$$

$$E_{PEAK} = t_1 \times V/S = t_1 \times \frac{E_x A_1}{R_{41} C_{12}}$$

$$E_{PEAK} = t_2 \times V/S = t_2 \times \frac{E_R A_1}{R_{41} C_{12}}$$

$$t_2 = \frac{E_x A_1 R_{41} C_{12} t_1}{E_R A_1 R_{41} C_{12}} = \frac{E_x t_1}{E_R}$$

$$t_1 = \frac{N}{f_{clk}} \qquad t_2 = \frac{\text{READOUT}}{f_{clk}}$$

$$\frac{\text{READOUT}}{f_{clk}} = \frac{E_x N/f_{clk}}{E_R}$$

$$\text{READOUT} = \frac{E_x N}{E_R}$$

offsets or slow drift occurring in A1 are amplified in A2 and the zero correcting circuits, and fed to the auto-zero. Similarly, the drift of A2 is amplified in the zero detection circuits and fed to the zuto-zero. E_s is the amplified sum of all the offsets occurring in A1, A2, and the zero detection circuits. The auto-zero compares E_s to ground, feeding back a correction voltage E_c to A1 to force E_s to equal zero volts. As long as the operation continues, the output of A2 cannot drift off zero.

4-1-2. MEASUREMENT CYCLE

When the measurement cycle starts, Q4 opens and Q3 closes, applying E_X to A1. Note that if E_X = 0V, the input voltage to A1 has not changed. As a result, A2's output will not move from zero volts and this will yield a perfect zero reading.

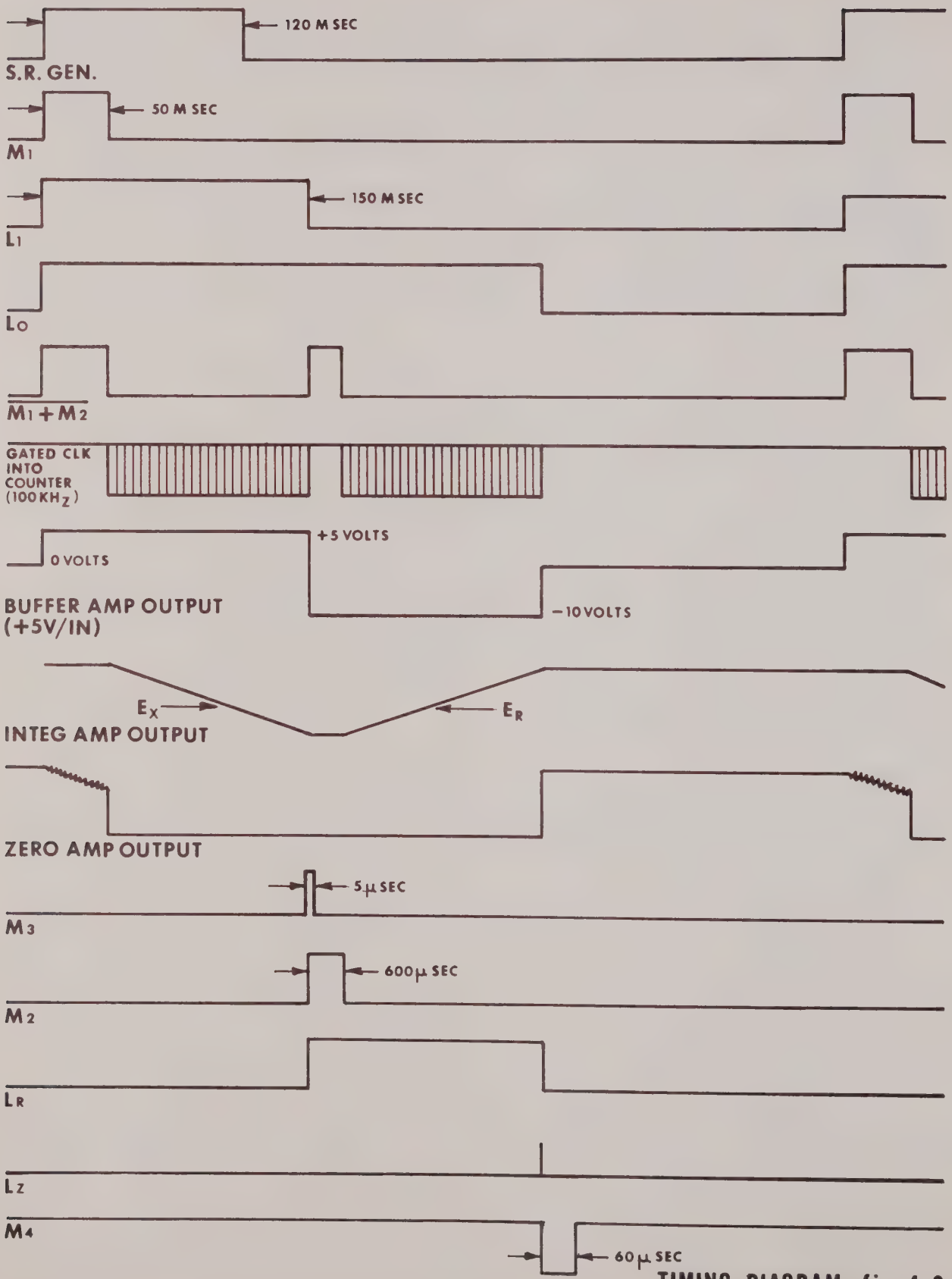
A1, in turn, applies the amplified E_X to the integrating amplifier A2. At the time that Q3 closes, a counter starts to count up from zero to 10,000 to provide the fixed time base, t_1. When the 10,000 count is reached, Q3 is opened and Q5 is closed to either $+E_R$ or $-E_R$ as required to make the output of A2 slew toward ground. As Q5 closes, the counter is reset to zero and again counts up from zero. When the charge on C12 is reduced to zero volts, the counting is stopped and the number accumulated in the counter is displayed on the readout.

4-2. SYSTEM THEORY

4-2-1. SEQUENCE OF OPERATIONS

Refer to Figure 4.3. (timing diagram) and the functional block diagram #100-640 or Schematics #100-628 and #100-625. Voltmeter operations occur in the following sequence:

a. Before a new measurement cycle is started, the readout displays the value obtained from the previous cycle, which is stored in the DATA STORAGE REGISTER. Q4 and Q3 are on and the auto-zero circuit is correcting A1 so that the first stage of the zero Schmitt trigger circuit is half way between its true and false values. Note that L_o, L_1, and L_R are in their false state between encodings.



TIMING DIAGRAM fig 4.3

b. The sample rate generator applies a positive pulse to the input of M_1 to start a series of events which precede a measurement. These pulses are produced at a rate controlled by the setting of the sample rate potentiometer. (In many OEM instruments this front panel potentiometer has been replaced by a fixed resistor.)

c. M_1 fires upon receipt of a positive pulse at its input, driving the M_1+M_2 gate true. M_1 also sets L_1 which then sets L_o, turning off switch Q4 and Q23 and turning on switch Q3, applying E_X to A1. In system usage, M_1 provides a delay from the encode command to the beginning of the encoding, so that the input filters have time to settle.

d. When M_1+M_2 gate is driven true, it applies a reset pulse to all counters and to the overrange flip-flop, resetting them all to zero. M_1+M_2 also closes the clock gate to prevent any pulses from reaching the counter during M_1 time. M_1+M_2 gate also opens switch Q17 to prevent the integrating amplifier from integrating the input while the filter is slewing.

e. At the end of M_1 time the clock gate allows pulses to be fed to the counter and switch Q17 turns on, starting the integration of the output voltage from A1 which equals the gain of A1 times the attenuated E_X.

f. After 10,000 counts, the negative going edge of X_{83} will fire M3, causing L_1 to reset. L_1 resetting turns off Q3.

g. As L_1 resets, the positive going transition of $\overline{L_1}$ will fire M_2. M_2 resets L_R, turning on Q5. M2 again drives M_1+M_2 gate true, cutting off clock pulses to the counter and turning off Q17, stopping any further integration of A1's output. The zero detection circuits detect the polarity of the integrator's output and select $+E_R$ or $-E_R$ as required to make the integrator output slew toward zero. D4 and Q4 connect $+E_R$, and D3 and Q3 connect $-E_R$. M_1+M_2 gate going true also resets all counters to zero.

h. At the end of M_2, M_1+M_2 gate goes false, again allowing clock pulses to flow into the counter via gate Z10A and Z10B and turning Q17 on. Simultaneously, the negative going edge at the end of M_2 causes the polarity information from the zero Schmitt ($\overline{L}_z$) to be transferred into the polarity flip-flop, L_p, whose output controls the + and - symbols.

i. Integrator capacitor C12 starts to discharge toward zero volts and the counter starts counting up from zero, continuing until the integrator output crosses zero. At that time the zero-Schmitt changes state, resetting L_R. The positive going edge of $\overline{L}_R$ resets $\overline{L}_o$, turning on Q8 to prevent further pulses from getting to the counter. Also, the negative going edge of L_R fires M_4, causing a store pulse to be sent to the storage registers. This causes the new reading to be transferred from the counters to the storage registers and displayed. L_o also turns on Q4 and Q23 returning the meter to the condition described in 4-1-1; L_R at the same time turns off Q5.

4-3. CIRCUIT DESCRIPTION

All the voltmeter circuits in the DS-100 main frame and the plug-in modules are floating and guarded with respect to the AC power source. Power for the voltmeter is supplied through a triple-shielded transformer which is specially designed to minimize capacitance to power ground and current leakage from the AC power source. The guard surrounding the measuring circuitry is connected to the center of the three transformer shields and to the guard terminal on the front panel, and may be extended to the common mode source.

For discussion purposes, the voltmeter circuits have been divided into three sections; analog, digital, and power supplies. Analog ground is connected to the "LO" terminal on the front panel. Digital "ground" is on the -24V supply, for reasons which will become apparent later. For simplicity, digital ground will be referred to as -24V. Most of the digital circuits and power supplies are physically located on the top digital board.

MAINTENANCE NOTE

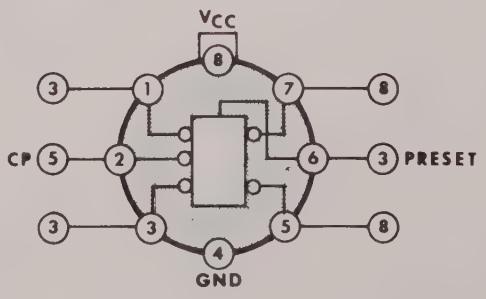
When measuring digital waveforms, the oscilloscope MUST be grounded to the -24V supply. However, the oscilloscope should be operated on an isolator plug or transformer in order to prevent any possible ground loop from shorting the -24V supply. Momentary shorting of the -24V supply will not cause damage, as the power supply has limiting protection.

4-4. DIGITAL CIRCUITS

Five types of digital integrated circuits are used in the DS-100; all are resistor-transistor logic (RTL), having positive (high) true logic levels.

a. The first logic type is the μL923 J-K flip-flop. Refer to Figure 4.4. Positive supply is on pin 8, and negative on pin 4. Outputs are on pins 7 and 5, only one of which should be true at a given time. The enable inputs for these outputs are pins 1 and 3, respectively. A low voltage on one of these pins will enable a negative going clock edge on pin 2 to set the related output to the low state. If both enable inputs are in the low (enabling) state, the flip-flop will toggle from one state to the other on successive clock pulses. Pin 7 output may be

LOGIC SYMBOL & LOAD FACTORS



TRUTH TABLE

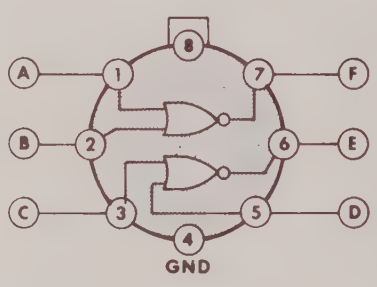
SET (1)	CLEAR (3)	OUTPUT (7)
	t=n	t=n+1
H	H	X^n
H	L	H
L	H	L
L	L	X^n

H is more positive than L.
X is the output state at time n.

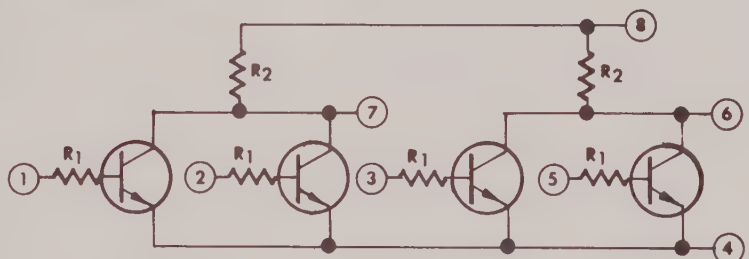
μL923 J-K FLIP FLOP fig 4.4

set to the low state by applying a high state to pin 6. This may be used as either a reset or preset depending on which output pin is defined as the true output.

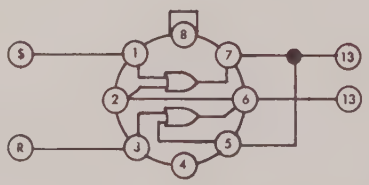
b. The μL914 contains two double input NAND/NOR gates. (Refer to Figure 4.4.) If pins 1 and 2 are low, the output will be high. If pins 1 or 2 is high, the output will be low. The same is true of the second gate. A frequent use of type μL914 is as an RS flip-flop (set/reset). See Figure 4.5. If one input to each gate is cross coupled to the output of the other gate, positive feedback will occur, causing flip-flop operation. If either free input is taken high, the corresponding output will go low. If both inouts are low, the last state will be stored. The normal logic levels for the μL914 and the μL923 are: 1.2V = high; 0.2V = low.



SCHEM DIAGRAM



R_1 = 450Ω
R_2 = 640Ω



INPUT		OUTPUT	
1	3	6	7
L	L	NC	NC
L	H	L	H
H	L	H	L
H	H	NOT ALLOWED	

NC = no change

μL 914 DUAL 2 INPUT GATE fig 4.5

c. Type CμL958 is a decade counter consisting of four cascaded binary triggered flip-flops modified by a feedback loop to count in the 8-4-2-1 code. See Figure 4.6. The false side of all flip-flops is brought out; a low state on an output indicates the bit is true. The count terminal (pin 9) provides an input for pulses while the reset terminal (pin 12) allows the counter to be reset to zero. Normal logic levels are 1.2V = high, 0.2V = low.

d. A Type CμL959 storage unit consists of four gated latch circuits, and a common gate driver. (See Figure 4.7.) Information which is present at the four data inputs enters the latches during the interval that the hold command is removed from the gate input terminal, pin 1. The hold command is a high

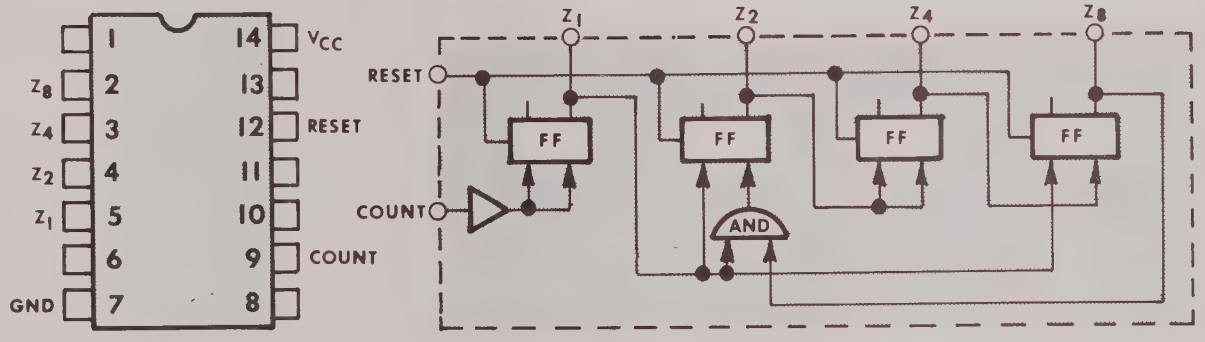
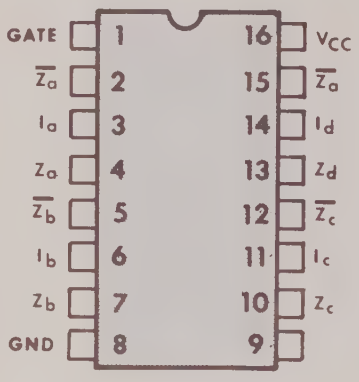


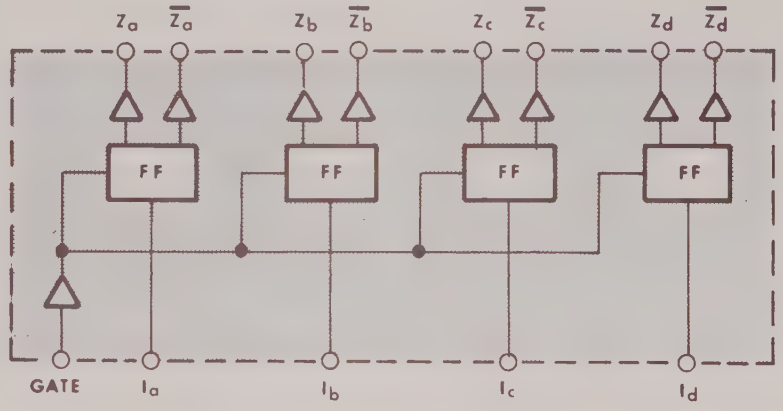
TABLE OF OUTPUT STATES

COUNT→	0	1	2	3	4	5	6	7	8	9
Z_1	H	L	H	L	H	L	H	L	H	H
Z_2	H	H	L	L	H	H	L	L	H	H
Z_4	H	H	H	H	L	L	L	L	H	H
Z_8	H	H	H	H	H	H	H	H	L	L

H = High
L = Low

CμL 958 DECADE COUNTER fig 4.6



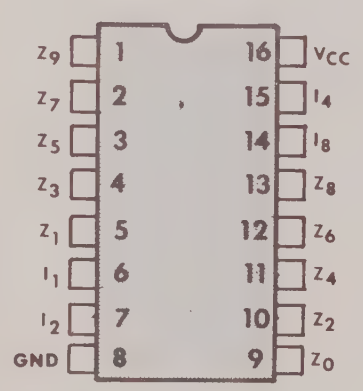


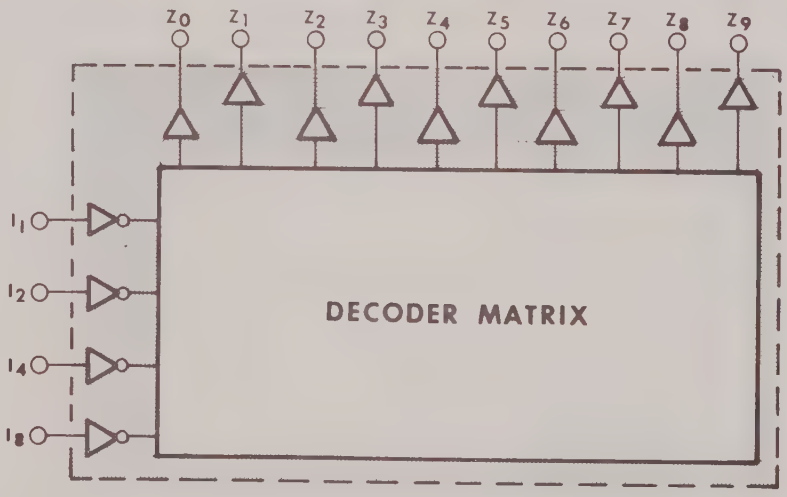
TRUTH TABLE

GATE	I	Z	$\overline{Z}$
L	L	L	H
L	H	H	L
H	ANY	Q	$\overline{Q}$

H = High
L = Low
Q = The state assumed prior to "GATE HIGH" is maintained.

CμL959 STORAGE REGISTER fig 4.7





TRUTH TABLE

I_1	H	L	H	L	H	L	H	L	H	L
I_2	H	H	L	L	H	H	L	L	H	L
I_4	H	H	H	H	L	L	L	L	H	H
I_8	H	H	H	H	H	H	H	H	L	L
on output	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9

H = High
L = Low

CμL960 DECODER/DRIVER fig 4.7A

state. With gate input high, information is stored until pin 1 is taken low. Both the true and false sides of the latches are brought out; normal logic levels are 1.2V = high, 0.2V = low.

e. Type CμL960 decoder/driver is an integrated circuit which accepts negative (low) true 8-4-2-1 BCD inputs and produces high level ten-line outputs which can directly drive a Nixie tube (see Figure 4.7A). Normal input levels are identical to the μL959's; normal output levels are low = +4V max, high = +55V min.

4-4-1. SEQUENCING LOGIC CIRCUITS (Schematic #100-628)

a. SAMPLE RATE GENERATOR

The sample rate generator is a free-running multivibrator made up of a Schmitt trigger and an active integrator; Schmitt trigger is formed by inverters Q1 and Q2, with positive feedback supplied by R6. Input is applied on R4. Output of the Schmitt is fed through R9 and R10 to the integrator made up of C1 and Q3. Since the integrator always slews in such a direction as to cause the Schmitt to change state, the output of Q2 is a rectangular waveform which has a period roughly proportional to R9 + R10. As R9, the sample rate potentiometer approaches 100K, the oscillation stops due to lack of base drive for Q3; this is the HOLD position.

b. M1 MONO

Mono 1 is formed by an R-S flip-flop driving an active integrator, Q4 and an emitter follower Q5. Pin 7 of Z1A is normally true, causing the emitter of Q5 to be at -24V. A differentiated positive pulse from the sample rate generator on pin 2 sets the flip-flop and causes the integrator to slew positive, eventually resetting the flip-flop through pin 5. Circuit time constant is 55 milliseconds, and the output is fed to the clock through C4 as a sync signal. (In high speed meter with option E, the time constant is 5.5 ms.)

c. M2 MONO

Mono 2 is essentially the same as Mono 1 except that it is modified for a shorter time constant of 600 μs. The clock is fed to its output through C15 as a sync signal.

d. DUAL DIFFERENTIATOR

The dual differentiator is made up of the two gates in Z4. $\overline{L}_z$ from the zero crossing Schmitt is fed into pin 5 of Z4A to form L_z. L_z and $\overline{L}_z$ are then differentiated by C7, R19 and C6, R18. Resulting waveforms are fed to pins 1 and 2 of Z4B, and are amplified and inverted. Thus a positive pulse on either L_z or $\overline{L}_z$ becomes a negative pulse at pin 7, Z4B, and is sent to the toggle input (pin 2) of the reference flip-flop, L_R. Note that pin 7, Z4B is normally positive.

e. M4 MONO

Mono 4 creates a pulse to transfer the measurement from the counters to the buffer storage at the end of the encoding. This is accomplished by differentiating the negative going edge of L_R through C17 and R42 and amplifying it in Z11. Two gates are used as two inverters in series. Pin 7 is normally at -24V while pin 6 is normally positive. R41 and C18 provide a 2 μs delay in the store pulse so that any carry pulses traversing the counter at the end of the encoding can die out before the information is transferred to the data storage registers.

f. CLOCK

A two-inverter multivibrator forms the basis of the clock, with a parallel L-C circuit in the feedback of one inverter, Z5B, to control the frequency, along with C8. Two gates of Z5 are used as the inverters. The clock frequency is set at 100 KHz, thus generating a pulse to the clock gate at 10 microsecond intervals.

In the high speed Option E, a stable crystal resonant at 600 KHz replaces C8. This version of the instrument provides excellent normal mode noise rejection at 60 Hz and its multiples, as well as providing much faster overall measurement speeds.

g. CLOCK GATE AND BUFFER

The clock gate and buffer are made up of Q8, gate Z10A and gate Z10B. Two

resistors on the base of Q8 form a NOR gate. Between encodings, $\overline{L}_o$ is high, turning on Q8. When $\overline{L}_o$ goes to -24V, the clock signals drive Q8 through R31. Output of Q8 is fed to Z10A, which is gated by the M_1+M_2 gate signal; output of Z10A is fed back to the base of Q8 to provide AC positive feedback in order to square the signal. Z10B provides inversion to give the proper phase relationship.

h. OVERLOAD DETECTOR

The overload detector circuit logically ANDs $\overline{X_{14}}$ (10,000 counts) with $\overline{X_{23}}$ (2,000 counts) in gate Z12A to produce a positive output pulse after 12,000 counts. This positive pulse is applied at the set input to the R-S flip-flop, L_{OL}, to produce an overload indication. L_{OL} (Z13) drives Q14 to turn on the overload neon, providing a visual indication. Overload indication is stored until M_2 fires approximately halfway through the next encoding. M_2 resets L_{OL}. C31 prevents spurious set pulses from reaching L_{OL} while $\overline{X_{14}}$ and $\overline{X_{23}}$ are being reset.

i. POLARITY DETECTION

Information for polarity determination is available on the $\overline{L}_z$ line at the beginning of M_2. Gate Z4A of the dual differentiator inverts $\overline{L}_z$ and provides the enable inputs of the L_P flip-flop with both L_z and $\overline{L}_z$. The leading edge of $\overline{M}_2$ causes the new polarity information to be set into L_P. Polarity information is then displayed, with Q10 or Q11 turning on the appropriate neon.

j. OVERFLOW ONE

Principle of operation of the "overflow one" storage flip-flop, Z27 is the same as described above. X_{14} and $\overline{X_{14}}$ from flip-flop Z26 are applied to the enable inputs of Z27; leading edge of the store pulse causes the information to be transferred from Z26 to Z27 flip-flop. High voltage driver, Q19 displays the information through the "1" neon.

k. MISCELLANEOUS FLIP-FLOPS

L_1 and L_{OL} are R-S flip-flops made up of μL914 gates as described in

section 4-4-b. L_R, L_P, X_{14} and Y_{14} are J-K flip-flops, as described in section 4-4-a. L_o is formed by a pair of gates and is true when L_R and L_1 are false.

4-4-2. DISPLAY COUNTER

The display counter is made up of four identical decades. Each decade is made up of an 8-4-2-1 BCD counter, a gated latch storage unit and a BCD to decimal decoder-driver. The counter accepts pulses from the clock gate and buffer output and divides the frequency by 10 (See Functional Block Diagram, 100-640). Output from the 8 bit is fed to the next decade. All four bits are fed to the storage unit. When the hold input goes false (-24V) at the end of the encoding, the four bits in the counter are transferred into the flip-flops in the storage unit. When the hold input is returned true (-22V), the storage unit ignores any changes in the state of the counter. Outputs of the storage unit are connected to the decoder-driver inputs. The decoder-driver contains internal logic which converts the binary information into one-out-of-ten information. Output is in the form of ten high-voltage driver lines which are connected to the ten cathodes of a Nixie tube.

4-5. POWER SUPPLIES (Schematic #100-628)

The power supplies include half or full bridge rectifiers with standard capacitor-input filter circuits. In addition, the integrated-circuit supply contains a high gain regulator circuit. All the voltage gain is in Q16 which has a constant current generator, Q15, as the collector supply. Q17 lowers the output impedance of the amplifier and drives the passing transistor, Q18. Q16 compares the output voltage, reduced by R66, R67, R68, with the reference voltage created by CR10, CR11. If the output voltage deviates from 4V, Q16 reacts to correct it. These supplies are located in the digital board assembly.

4-6. ANALOG CIRCUITS (Schematic #100-625)

Most of the analog circuits of the basic voltmeter are contained on two boards, the analog board and the reference board. Raw ±35V supplies for these boards are supplied by the digital board, and regulation is supplied by the analog board. The regulated 4V integrated circuit supply voltage, generated on the digital board, is also routed to the analog board.

4-6-1. ANALOG BOARD, SERIES "K"

4-6-1-1. ATTENUATORS

Those meters which have 100V and 750V ranges, will have a ten megohm input attenuator, composed of the 10 megohm R1, 100.909K R2, and calibration potentiometer R3. Relay K1 allows the attenuator to be by-passed on the lower ranges to provide higher input impedance. The calibration potentiometer sets the attenuator to perform a precise 100:1 division, the divider being inserted in front of the DVM on both the upper voltage ranges.

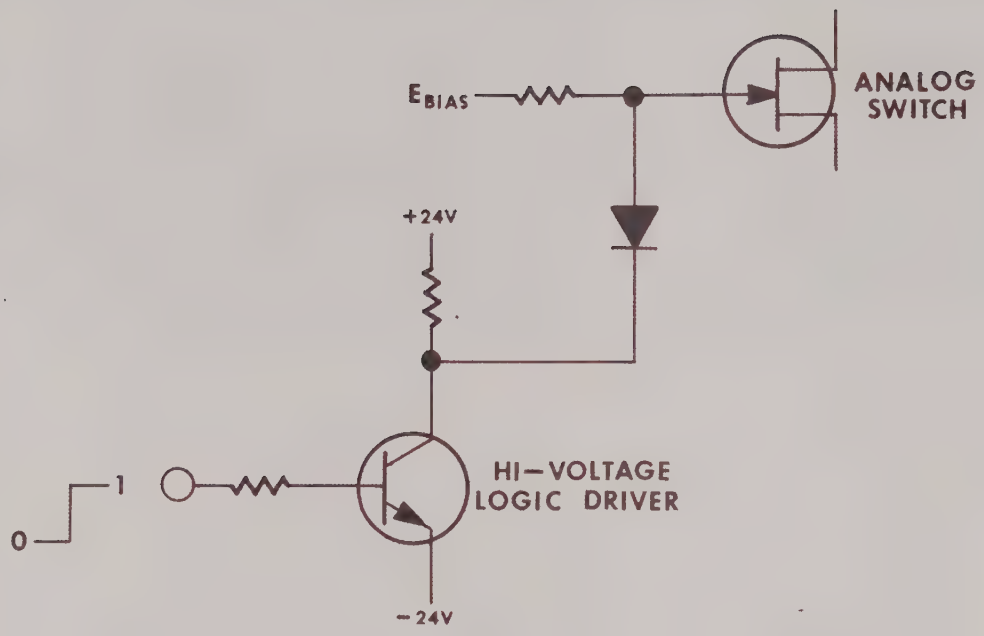
4-6-1-2. FILTER

The filter-limiter circuit is made up of a two-section low pass filter (R4, C1, R5, C2) with an overload protection limiter attached to the output of the first section. This prevents high voltage from damaging the buffer amplifier. FET's Q1 and Q2 connected as diodes, limit the voltage at this point to ±15V.

4-6-1-3. ANALOG SWITCHING

There are 8 analog switching channels in the instrument, which are all essentially identical (see Figure 4.8). Each channel is formed by a high-level driver and a junction field-effect transistor (FET) switch. Drivers convert I.C. logic levels to high voltage swings; the FET switches convert these high voltage swings to solid state "closures".

In Figure 4.8, when the driver output is positive, D1 is reverse biased, causing the gate to be zero-biased with respect to the source. As a result, a low impedance, (<1.0K) appears between drain and source. When the driver is negative, D1 pulls the gate negative, causing several thousand megohms to appear between drain and source. Either C1 or C2 may be incorporated in the driver, depending on what timing is required for proper operation. Note that S2 and S6 are both controlled by D2. Switch drivers include Q25 through Q30; the FET switches include Q3, Q4, Q5, Q17, Q18, and Q23 on the main analog board, and Q3 and Q4 on the reference board.



ANALOG SWITCHING CHANNEL fig 4.8

4-6-1-4. BUFFER AMPLIFIER

The buffer amplifier is a multiple-stage differential amplifier connected in the potentiometric feedback mode. The first differential stage is the dual field-effect transistor Q6A and Q6B. It is operated as a long-tailed pair with the constant current generator Q11 supplying the current to the sources. A second differential pair, Q7 and Q8, is driven by the output of the first pair. Collectors of Q7 and Q8 supply negative feedback to the sources of the first stage via R16 and R25. Resulting stabilized gain on these stages is approximately 300, and roll-off is provided by C4-R24 with CR4 and CR5 to give fast recovery from overloads. A third differential pair, Q13 and Q14 are driven by Q7 and Q8. Q14 in turn drives Q15 a common emitter stage. R28-C7 and R3 R31-C6 provide further roll-offs for shaping the frequency response. Q16 is an emitter follower which lowers the output impedance of Q15. Q10 and Q12 are cascaded emitter followers driven by the sources of the dual FET Q6A and Q6B. Output of Q12 drives zener diodes CR9 and CR8 to provide a floating supply for the first three amplifier

stages. Current for the zeners is supplied by constant current generator Q9. Since the anode of CR9 always tracks the sources of Q6A and Q6B, the cathode of CR8 must be a constant 12.4V positive of the sources, allowing Q6A, and Q6B, Q7, Q8, Q13, and Q14 to operate with a constant supply regardless of the voltage between the gates of Q6A/Q6B and analog ground.

Overall amplifier gain is selected by feeding back from one of four points on the output attenuator (R79, R80, R81, R82, and R83) to Q6 input. Selectable gains are 1.08, 10.8, 108 and 1080. The correction voltage, E_c, is summed into the feedback attenuator.

4-6-1-5. INTEGRATING AMPLIFIER

The integrating amplifier is a high input impedance, high gain operational amplifier. Its first stage is a field-effect source follower Q18 which has a very high input impedance and very low current offset (<40PA). The source-follower has a typical gain of 0.9. Its output drives the inverting input of an integrated-circuit operational amplifier Z1, which has a typical open loop gain of 20,000 and a typical output swing of ±12V. Capacitor C12 supplies negative feedback to the summing junction (gate of Q18) and R41 sets the full-scale current.

4-6-1-6. ZERO CROSSING AMPLIFIER

The zero crossing amplifier is a wide-band DC amplifier which detects the zero-crossings of the integrator amplifier. CR13, CR14, R47 and R48 form a current limiter to prevent overload of the integrating amplifier or damage to Q19. Q19 is a common-emitter stage which has an output buffer, Q20, to lower the output impedance. A DC level shifter formed by CR15 and CR16 drives the second common emitter stage, Q21. Local feedback stabilizes the gain at 10,000.

4-6-1-7. ZERO SCHMITT TRIGGER

The zero Schmitt trigger squares up the amplified zero-crossings to provide a logic level transition at the exact moment the integrator output crosses zero. It is formed by Z3A and Z3B. Positive feedback via R56 assures sharp transitions. While $\overline{L}_R$

is positive, G2 is held in the low state (negative), preventing the positive feedback action and allowing Z3A to act as a linear amplifier feeding Q22 in the auto-zero circuit. Z4A is an inverter to drive D4, for polarity selection.

4-6-1-8. AUTO-ZERO CIRCUIT

The auto-zero circuit is a single-stage voltage amplifier followed by a simple sample-and-hold circuit. Q22 is a common base stage with a gain of 50; it is rolled-off by R61 and C16. Q23 is a standard analog switch (described in 4-6-1-3), connecting the output of Q22 to the storage capacitor C17. Q24 is a high input impedance source follower which supplies the correction voltage E_c to the buffer amplifier. When an encoding starts, Q23 is turned off, and the last voltage required to zero the system is stored on C17. Thus, a continuous correction voltage is applied to the buffer amplifier.

4-6-1-9. OFFSET CIRCUIT

All Doric instruments with a sensitivity of greater than 10 μV/digit contain an offset circuit to buck out external thermal voltages. This circuit is made up of R9 through R14. By moving the wiper on R13 from the center to one end or the other, a change of ± 10 μV can be induced across R11. Since this voltage is in series with the input terminals, it can be used to buck out any thermal voltages in the input circuit.

4-6-1-10. 24V and 15V REGULATORS

The +24V and +15 regulators consist of a constant current supply, Q44, driving a 24V zener diode, CR41, followed by two emitter followers Q46 and Q47. Emitter followers are used to lower the output impedance. CR35, CR36, CR37 and R102 supply a constant voltage (with respect to +35V) for Q44. Since the diode drop of CR37 cancels the V_{BE} of Q44, two diode drops appear accoss R106, thus creating a constant current which flows through the collector of Q44 to CR41, causing it to zener at 24V. The output of CR41 feeds emitter follower Q46 which creates the +24V supply. The +15V supply is created by Q47 which derives its voltage from the divided-down +24V supply. The -24V and -15V supplies are identical to those described above except that the

polarities are reversed and NPN's replace PNP's and vice versa. The ±35 volt raw supplies for the above regulators are created on the digital board.

4-6-1-11. M_3 MONO

M_3 mono is an I.C. gate used as an inverter. R66 forces the input of the gate true, holding the output false. X_{83} going false causes a negative going edge on C18; this causes a differentiated spike to appear at the input of the gate. The gate will square up this spike to produce a rectangular 3 microsecond pulse, L_1 reset.

4-6-2. REFERENCE BOARD (Schematic #100-626)

The reference board contains a precision zener supply, reference polarity selection and the calibration networks. On the same board are the ratio amplifier and ratio calibration network when option "C" is included. The function of this board is to provide a highly stable voltage of a polarity and magnitude appropriate for comparison with the unknown voltage.

4-6-2-1. ZENER SUPPLY

The precision zener supply consists of a temperature-compensated constant current supply delivering an accurate current to an aged and temperature-compensated zener diode. A constant voltage -7.4V with respect to +24V, is developed across CR2, CR3, and CR4 and is applied to the base of Q1. The emitter of Q1 then develops a constant 6.8V across R1, R2, and R3, which are selected to deliver the exact current through CR1 for a zero temperature coefficient. Constant current flowing through CR1 will create a 6.2V output voltage which typically changes less than 5 parts per million/°C (2.2/ppm/°F).

4-6-2-2. CALIBRATION CIRCUITS

The 10V range calibration adjustment is a simple resistive divider with an output settable to precisely 5V, which is delivered into the constant 20K input impedance of the polarity selection network. This 10V calibration potentiometer (R7) is the "basic" calibration adjustment, which will change all ranges by the same percentage.

4-6-2-3. POLARITY SELECTION NETWORK

The polarity selection network changes the I.C. operational amplifier, Z1, from a potentiometric gain of 2 to an operational gain of -2. Polarity selection switches Q3, Q4, are the standard analog switches (see 4-6-1-3) which are used to switch the non-inverting input (pin 3) of the operational amplifier. When Q3 is on and Q4 is off, pin 3 is pulled to ground through R14, forcing the summing junction (pin 2) and one side of R13 to ground. Since the other side of R13 is connected to the +5V internal reference, 250 μa will flow into the summing junction. All of this current will flow out through R57, creating -250 μa x 40K = -10V potential at the output of the amplifier. Since R15 and R16 have no voltage across them, they have no effect when Q3 is on. When Q4 is on and Q3 is off, pin 3 of the amplifier is pulled to +5V, forcing pin 2 to +5V, putting 5V across R15 and R16, and 0V across R13. R57 must deliver +250 μa in order to develop the 5V across R15 and R16. +250 μa x (R15 + R16 + R57) = +10V. R16 allows the plus gain to be adjusted to match the minus gain. No current is drawn through R13, so that Q2 is turned on in this polarity, connecting R8 to ground, and maintaining the 20K input impedance.

4-6-2-4. REFERENCE DIVIDER

The reference divider is a simple, but precise, resistive divider which accepts the ±10V from the reference amplifier and derives from it ±1V, ±.1V and ±.01V. These voltages are adjustable by the range calibration potentiometers R29, R31, and R22, respectively.

4-6-2-5. RATIO OPTION (Schematic #100-626)

The ratio amplifier is an IC operational amplifier working in the potentiometric "gain of one" mode. Bias current for the non-inverting input is obtained from a temperature-compensating source, which supplies a current varying with temperature to track the bias requirements. Exit currents from the external reference input are thereby minimized. Output of the amplifier is divided down 2:1 by R43 through R46. When ratio function is selected, 5V is fed to the polarity selection circuits when 10V is applied on the input.

4-6-3. ANALOG BOARDS, SERIES "P", PROGRAMMABLE (Schematic #100-636)

The "P" plug-ins are remotely programmable, and change ranges by means of electronic switches and relays. Remote range information is transmitted from the I/O board in 8-4-2-1 BCD code. A BCD to decimal integrated circuit decoder Z2 converts this to a "1 out of 6" code. The output of the decoder drives electronic switches to select the appropriate buffer amplifier gain and reference voltage as shown below, and also drives the decimal points, "MV" neon and the attenuator relay. The "P" option also accepts the Auto-Range board to provide for automatic range changing.

BCD Range Code			Decimal Range Code						Voltage Range	MV	Gain	Ref. V.	Atten.
$R2^2$	$R2^1$	$R2^0$	R1	R2	R3	R4	R5	R6					
0	0	1	1						750.0V		x1	10V	100:1
0	1	0		1					100.00V		x10	1V	100:1
0	1	1			1				10.000V		x1	10V	1:1
1	0	0				1			1.0000V		x10	1V	1:1
1	0	1					1		100.00MV	1	x100	.1V	1:1
1	1	0						1	10.000MV	1	x1,000	.01V	1:1

4-7. SELF-CHECK SWITCH, OPTION B

The self check switch is a low-level push button switch which is in series with the "signal HI" input terminal. When actuated, the switch disconnects the meter from the "HI" terminal and connects it to the reference zener. If the meter is now placed in the 10V range, it will read its own zener voltage, (nominally 6.2 volts). This reading should agree with the last voltage recorded on the calibration log located on the reference shield. This procedure checks the basic range calibration except for the zener.

4-8. HIGH SPEED, OPTION E (Schematic #100-625 and 100-628)

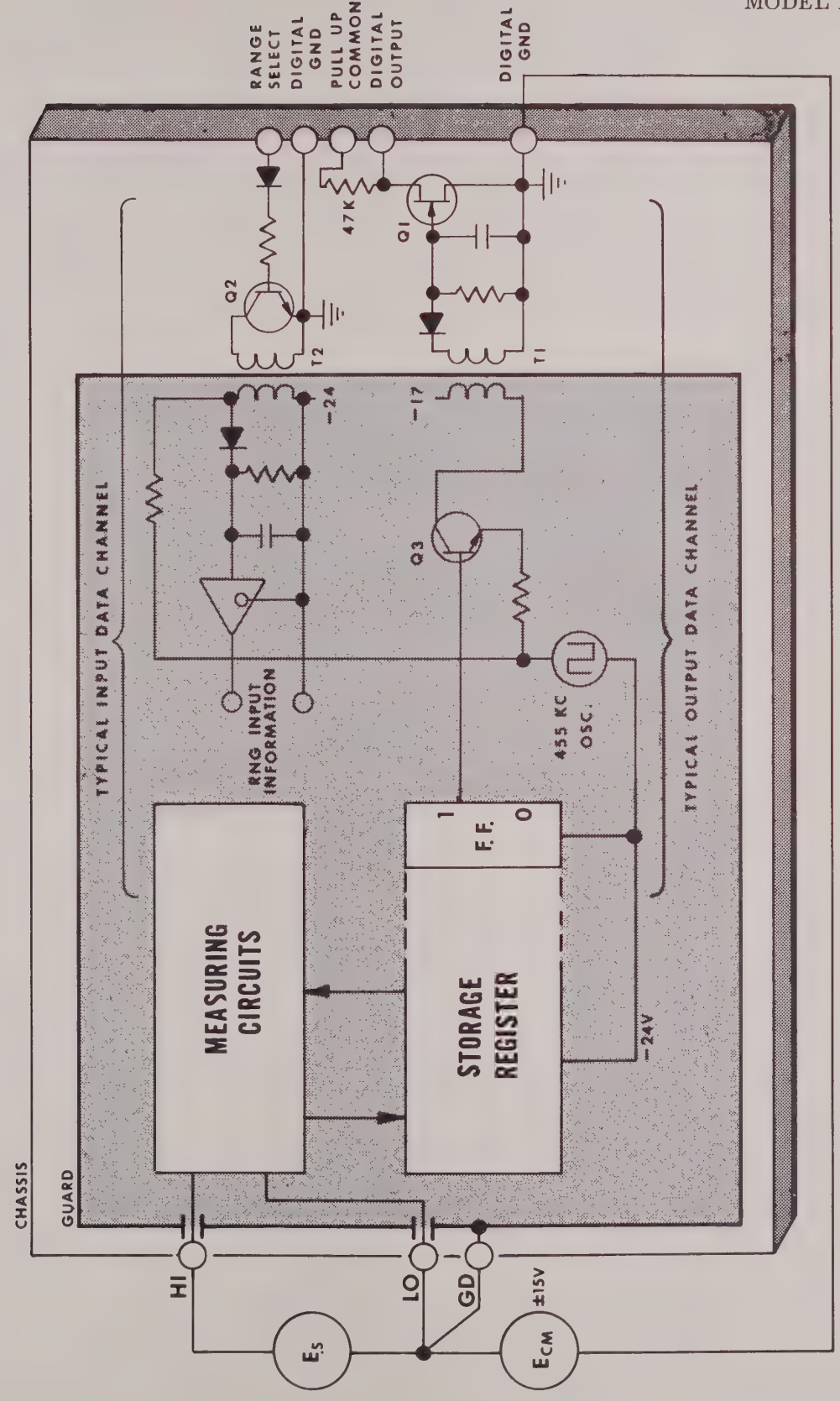
The high-speed option E has a crystal controlled clock to provide a precise 16.666 MS integration time. This provides excellent normal mode rejection at 60 Hz and multiples of 60 Hz and allows overall 50 MS reading speed. Other changes with option E include shortened time constants on the sample rate generator (0 to 20 Hz), M1 (5 MS),

integrator time constant (22 MS), auto-zero time constant (1.5 MS), filter time constant (≈.5 MS). In other respects, option E is identical to the slower meter.

4-9. I/O BOARDS S4-1, S4-1, S4-2 (Schematic #100-636)

Figure 4-9 shows a block diagram of the isolated digital guard-crossing. A typical output data channel is shown. When true, the flip-flop drives the base of Q3 positive, causing AC current from the oscillator to flow into transformer. As a result, an AC voltage is developed on the secondary which is rectified, filtered and used to switch off Q1. When the flip-flop goes false, Q3 is cutoff, causing a loss of AC signal to T1. This zero biases the gate of Q1, reducing its drain-source resistance to less than 200Ω. The digital output will equal zero volts under this condition and the pull-up voltage under the previous condition.

The input data channels apply AC current to the secondary of T2, which may be effectively shorted by shorting the primary with Q2. The resulting AC on the secondary is amplified, rectified, filtered and used as a logic level.



SOLID-STATE GUARD CROSSING BLOCK DIAGRAM fig 4.9

SECTION V

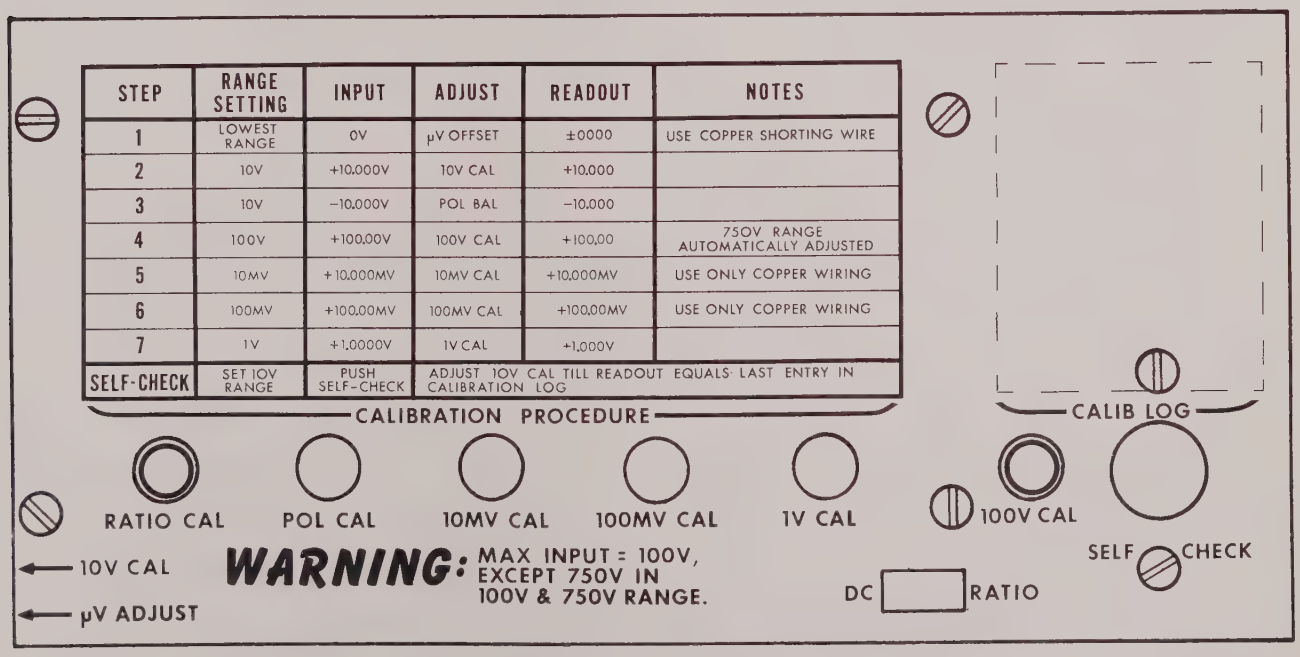
CALIBRATION

5-1. GENERAL

Basic calibration procedures are silk-screened on the internal calibration panel of each plug-in module as illustrated by Figure 5.1. This section provides a list of test equipment required for calibration and detailed instructions to supplement the basic procedures.

5-2. CALIBRATION PROCEDURES

The calibration procedure panel contains instructions for seven steps; given for each step is the range to which the meter is set, the input voltage, the name of the adjustment to be made, and the readout which must be obtained. For example, step 1 consists of (a) setting the range to 10MV, (b) shorting the input, (c) adjusting the μV OFFSET setting until (d) a readout of ±0.000 is obtained. The meter must be run for one hour


STEP | RANGE SETTING | INPUT | ADJUST | READOUT | NOTES
1 | LOWEST RANGE | 0V | μV OFFSET | ±0000 | USE COPPER SHORTING WIRE
2 | 10V | +10.000V | 10V CAL | +10.000 |
3 | 10V | −10.000V | POL BAL | −10.000 |
4 | 100V | +100.00V | 100V CAL | +100.00 | 750V RANGE AUTOMATICALLY ADJUSTED
5 | 10MV | +10.000MV | 10MV CAL | +10.000MV | USE ONLY COPPER WIRING
6 | 100MV | +100.00MV | 100MV CAL | +100.00MV | USE ONLY COPPER WIRING
7 | 1V | +1.0000V | 1V CAL | +1.000V |
SELF-CHECK | SET 10V RANGE | PUSH SELF-CHECK | ADJUST 10V CAL TILL READOUT EQUALS LAST ENTRY IN CALIBRATION LOG
CALIBRATION PROCEDURE
CALIB LOG
RATIO CAL
POL CAL
10MV CAL
100MV CAL
1V CAL
100V CAL
SELF CHECK
10V CAL
μV ADJUST
WARNING: MAX INPUT = 100V, EXCEPT 750V IN 100V & 750V RANGE.
DC
RATIO

INTERNAL CALIBRATION PANEL fig 5.1

with the plug-in closed, to obtain a stable internal temperature. After warm-up, the plug-in latch is released, causing the unit to slide out about 1-1/2 inches to give access to the calibration controls.

NOTE

This will allow cooler air to circulate within the instrument, which will tend to upset the thermal balance. For this reason, calibration of the 10MV range only should be completed as quickly as possible. If calibration on that range cannot be completed within one minute, the plug-in should be closed and the instrument allowed to warm up again before proceeding.

5-3. EQUIPMENT REQUIRED - ALL K SERIES & P SERIES PLUG-INS

A DC voltage calibrator is required with sufficient dynamic range to cover the DVM ranges; a typical example for 100MV to 1000V ranges would be Fluke 332B, Cohu 303B or 304.

10MV Range. Most commercially available calibrators are not sufficiently quiet or thermally stable for calibration to .01% on the 10MV range. Generally, the only suitable equipment is a low-thermal microvolt laboratory-type potentiometer, such as Honeywell 2768 or 2773.

5-4. CALIBRATION OF SINGLE-RANGE PLUG-INS

a. Follow warm-up procedure as in 5-2.

b. If unit is 10MV FS, short the input before opening plug-in. Open plug-in and adjust the μV OFFSET control for proper zero as shown in calibration procedure step 1 (see Figure 5.1), making the adjustment as quickly as possible.

c. If unit has a range greater than 10MV FS, proceed to step d.

d. Remove short from input and connect a DC calibrator with sufficient voltage output for full scale of the range to be calibrated. Set calibrator for the exact positive full scale (+9999 or +10000) of the meter.

e. Adjust the 10V CAL control until the readout displays a positive full-scale reading identical to the positive voltage input.

f. Change the polarity of the input voltage from the calibrator to negative, but keep the voltage exactly the same as in step d., i.e., meter full scale.

g. Adjust the POL-BAL (polarity balance) control until the readout displays a negative full-scale reading identical to the negative voltage input.

5-5. CALIBRATION OF MULTI-RANGE PLUG-INS

a. Follow warm-up procedure as in 5-2.

b. If plug-in has a 10MV FS range, short the input before opening plug-in. Open plug-in and adjust the μV OFFSET control for proper zero as shown in calibration procedure step 1 (see Figure 5.1), making the adjustment as quickly as possible.

c. If plug-in has no 10MV FS range, proceed to step d.

d. Remove the short from the input, set plug-in to its 10V FS range, and connect a DC calibrator set to +10.000 volts DC.

e. Adjust 10V CAL control until the readout displays exactly +10.000 volts.

f. Change the polarity of the input voltage from the calibrator to negative, but keep the voltage exactly the same as in step d, i.e., -10.000 volts.

g. Adjust POL-BAL (polarity balance) control until the readout displays a negative reading identical to the negative voltage input, i.e., -10.000 volts.

h. Change range of plug-in to 10MV FS and set calibrator to +10.000MV. If no 10MV FS range, proceed to the section covering the lowest range of the instrument.

i. Adjust 10MV CAL control until readout displays +10.000MV.

j. Change range of plug-in to 100MV FS and set calibrator to +100.00MV.

k. Adjust 100MV CAL control until readout displays +100.00MV.

l. Change range of plug-in to 1V FS range and set calibrator to +1.0000 volts.

m. Adjust 1V CAL control until readout displays +1.0000 volts.

n. Change range of plug-in to 100V FS and set calibrator to +100.00 volts.

o. Adjust 100V CAL control until readout displays +100.00 volts. The 750V range will automatically be correctly calibrated if the 1V FS and 10V FS ranges are properly adjusted.

p. Push plug-in fully into place in instrument and secure latch. Allow 30 minutes additional warmup.

q. Recheck zeros and full scale calibration on all ranges.

r. If any readjustment on 10MV FS range is needed, pull out plug-in and readjust as quickly as possible, closing plug-in as soon as completed. Recheck and adjust until all zeros and full scale readings are correct.

s. On meters having self-check option, after completing calibration, set to 10V FS range, push SELF-CHECK button and note exact reading. Record reading and date on calibration log (see Figure 5.1).

NOTE

To use self-check, set meter to 10V FS range, press SELF-CHECK CHECK button. Reading should be within ±1 digit of the last recorded reading in the calibration log if calibrated correctly.

5-6. CALIBRATION OF RATIO RANGES

a. Follow same warmup procedures as in 5-2.

b. Apply a +10VDC signal to both the "Reference Input" and the "Signal HI" lines, with negative connected to "Signal LO", with meter switched to the 10V FS (1:1) range.

c. Switch meter to ratio mode by means of ratio switch located on the plug-in sub-panel.

d. Adjust the RATIO CAL control on sub-panel for a readout of 10.000. If all the DC voltage ranges have been correctly adjusted, they will now read out correct ratio values without further adjustment.

SECTION VI

TROUBLESHOOTING

6-1. INTRODUCTION

It is unlikely that your Doric instrument will need any repairs during its lifetime. In case the situation does arise, a novel program of trouble analysis has been worked out which is both effective and easy to follow. After the program will be found pin charts, voltage charts and hold condition checkout chart.

6-2. NOTES ON CIRCUIT ANALYSIS

Once a fault has been isolated to a given circuit, the following steps should be taken before replacing components:

1. Check the theory of operation, Section IV, and circuit description section given in fault isolation program. This will tell what the circuit is supposed to do and how it should operate.
2. Analyze the input waveform for proper voltage levels and rise or fall times.
3. Check for abnormal loads on circuit in question. The schematic will help in finding what the normal load is.
4. Trace signal path in the circuit, component by component with an ohmmeter to ensure that there are no abnormal opens or shorts.
5. Replace bad components as required.

6-3. TROUBLESHOOTING PROGRAMS

The following pages contain the programs, which, when worked through systematically, will locate a malfunction in any part of the instrument. Each initial item in each sequence contains a question, the answer to which is a simple yes or no. Each answer leads to the next step or path in the program, logically eliminating each possibility until the trouble is located.

FAULT ISOLATION PROGRAMS

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
1	Are all power supplies OK per paragraph 6-5?	7	2
2	Are all loads normal per paragraph 6-5?	3	6
3	Are fuses OK?	5	4
4	Replace fuses, return to 1.	-	-
5	Analyze bad power supply; correct fault and return to 1.	-	-
6	Analyze incorrect load; correct fault; return to 1.	-	-
7	Set front panel control to HOLD, check if circuit condi-conditions agree with paragraph 6-6.	8	Go to step shown in chart 6-6.
8	Is sample rate generator oscillating?	9	28
9	Is M_1 firing?	10	31
10	Does M_1 set L_1?	11	31
11	Does L_1 set L_o?	12	31
12	Does M_1+M_2 gate go true?	13	31
13	Does M_1 end correctly?	14	31
14	Does clock gate allow pulses to flow to counter?	15	31
15	Does 8-bit in 10^3 decade divide input frequency by 10,000?	16	99
16	Does 8-bit (X_{83}) fire M_3 on going negative?	17	99
17	Does M_3 reset L_1?	18	99
18	Does $\overline{L}_1$ positive-going transition fire M_2?	19	99
19	Does M_2 set L_R?	20	99
20	Does L_R turn on Q5 via D7?	21	31
21	Does Q5 cause A1 output to be same polarity as A2 output?	22	46
22	When A2 output slews towards -.5V, does it cause L_z and $\overline{L_z}$ to change state?	23	46

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
23	When L_z and $\overline{L_z}$ change state, does it reset L_R via dual differentiator?	24	88
24	When $\overline{L_R}$ goes positive does transition reset L_o?	25	31
25	Does $\overline{L_o}$ cut off clock pulses?	26	31
26	Does negative L_R transition fire M_4?	27	31
27	Does M_4 pulse transfer counter information into storage registers?	34	31
28	Is control potentiometer tuned fully CCW?	30	29
29	Turn control potentiometer fully CCW and return to 8.	-	-
30	Analyze sample rate generator, correct fault; return to 8.	-	-
31	Are waveforms from previous circuit OK?	32	33
32	Check operation of circuit in question using circuit description, correct fault and return to the step taken prior to 31.	-	-
33	Check operation of previous circuit, using circuit description, correct fault and proceed along YES route.	-	-
34	End of encoding sequence.	-	-
35	Refer to Section IV, Paragraph 4-4-1. Analyze Q1, Q2, Q3 and associated circuitry. Correct fault and return to step 8.	-	-
36	Refer to Section IV, Paragraph 4-4-1. Analyze M_1 circuitry, correct fault and return to step 8.	-	-
37	Refer to Section IV, Paragraph 4-4-1. Analyze M_1 and M_2 gate; correct fault and return to step 8.	-	-
38	Refer to Section IV, Paragraph 4-4-1. Analyze M_2; correct fault and return to step 8.	-	-
39	Refer to Section IV, Paragraph 4-4-1; analyze M_3, correct fault and return to step 8.	-	-
40	Refer to Section IV, Paragraph 4-4-1; analyze M_4, correct fault and return to step 8.	-	-
41 thru 45	Unassigned		

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
46	Is A2 output more positive than -.5V?	58	47
47	Is zero amplifier output approximately -20V?	48	66
48	Is pin 7 of Z3 true?	49	67
49	Is L_R true?	50	19
50	Is L_Z in opposite state to pin 7 of Z3?	51	60
51	Is $\overline{L_Z}$ in opposite state to L_Z?	52	61
52	Is D3 in opposite state to L_Z?	53	62
53	Is D4 in opposite state to $\overline{L_Z}$?	54	62
54	Is D4 at +24V?	55	63
55	Is R14 on reference board at +5V?	56	69
56	Is the output of ±10 volt reference at +10V?	57	70
57	Is output of A1 equal to reference voltage multiplied by the gain of A1? (For gain of A1, see range chart in Section I, Paragraph 1-3-2.)	80	65
58	Is output of zero amplifier approximately 0V?	59	66
59	Is pin 7 of Z3 false?	49	67
60	Check Z3, correct fault, and return to No. 50.	-	-
61	Check Z4, correct fault, and return to No. 51.	-	-
62	Replace faulty transistor and return to previous step.	-	-
63	Is R14 on reference board at 0 volts?	64	68
64	Is the output of ±10 volt reference at -10V?	57	70
65	Is D7 at +24V?	84	71
66	Analyze zero amplifier, correct fault, return to No. 47 or No. 58.	-	-
67	Analyze Z3, correct fault, return to No. 48 or No. 59.	-	-
68	Analyze Q3 circuit, correct fault and return to No. 63.	-	-
69	Analyze Q4 circuit, correct fault and return to No. 55.	-	-
70	Analyze Reference Amplifier, correct fault and return to No. 56 or No. 64.	-	-
71	Analyze D7 inverter, correct fault and return to No. 65.	-	-

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
72 thru 79	Unassigned		
80	Is A1 output applied to R42 (A2 input)?	81	93
81	Is A2 output slewing opposite direction to A2 input?	82	86
82	Does A2 output cross -.5V?	46	87
83	Deleted		
84	Is A1 input at same voltage as reference output? For reference voltage outputs, see No. 91.	85	92
85	A1 not operating correctly; short input to ground and go to No. 133.	-	-
86	Analyze A2, correct fault and return to No. 81.	-	-
87	If A2 output crosses -.5V but oscillates about that value, go to No. 88.	-	-
88	Is the $\overline{L_Z}$ oscillation reaching pin 5 of Z4, on the digital board?	89	95
89	Is pin 7 Z4 on digital board putting out differentiated pulses?	90	96
90	Does $\overline{L_R}$ go true?	24	97
91	Check reference voltages per range chart, Section I, Paragraph 1-3-2.	-	-
92	Q5 not "on". Analyze circuit, correct fault and return to No. 84.	-	-
93	Is D5 at +24V?	94	98
94	Q17 not "on". Analyze circuit, correct fault and return to No. 93.	-	-
95	Trace oscillation through connector wiring, circuit straps, etc., correct fault, return to No. 88.	-	-
96	Analyze dual differentiator, correct fault and return to No. 89.	-	-
97	Analyze J-K flip-flop, correct fault, return to No. 90.	-	-
98	Check M_1 and M_2, correct fault and return to No. 93.	-	-

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
99	Does 8-bit in 10^0 decade divide input by 10?	100	103
100	Does 8-bit in 10^1 decade divide input by 100?	101	104
101	Does 8-bit in 10^2 decade divide input by 1000?	102	105
102	Does 8-bit in 10^3 decade divide input by 10,000?	Dividers are OK	106
103	Analyze 10^0 decade counter, correct fault, return to No. 99.	-	-
104	Analyze 10^1 decade counter, correct fault, return to No. 100.	-	-
105	Analyze 10^2 decade counter, correct fault, return to No. 101.	-	-
106	Analyze 10^3 decade counter, correct fault, return to No. 102.	-	-
107 and 108	Deleted		
109	Is A1 output +3V or greater?	122	110
110	Is A1 output -3V or less?	111	122
111	Is base of Q16 -2.5V or less?	112	117
112	Is there a voltage drop across R28 of less than 2V?	113	118
113	Is base of Q14 greater than .1 volt negative with respect to base of Q13?	114	119
114	Is base of Q7 greater than .1 volt negative with respect to base of Q8?	115	120
115	Is gate of Q6B greater than .01 volt negative with respect to gate of Q6A?	116	121
116	Analyze A1 output divider string, correct fault, and return to No. 115 or No. 126.	-	-
117	Analyze circuits associated with Q16, checking for overloads, correct faults and return to No. 111 or No. 122.	-	-

Step No.	Procedure	If YES, Go. to Number	If NO, Go to Number
118	Analyze circuits associated with Q16, checking for overloads, correct faults and return to No. 112 or No. 123.	-	-
119	Analyze Q13 and Q14 circuits, correct faults and return to No. 113 or No. 124.	-	-
120	Analyze Q7 and Q8 circuits, correct faults and return to No. 114 or No. 125.	-	-
121	Analyze Q6 and Q7 circuits, correct faults and return to No. 115 or No. 126.	-	-
122	Is base of Q16 greater than +3.5V?	123	117
123	Is there a voltage drop across R28 of greater than 6V?	124	118
124	Is base of Q14 greater than .1V positive with respect to base of Q13?	125	119
125	Is base of Q7 greater than .1V positive with respect to base of Q8?	126	120
126	Is gate of Q6B greater than .01V positive with respect to gate of Q6A?	116	121
127	Is E_{cm} at 0 volts ±.2V?	109	128
128	Is junction of R12 and R13 at less than +4V and greater than 0V with respect to ground?	129	134
129	Is emitter of Q10 .5V negative with respect to R12 and R13?	130	135
130	Are Q12, CR8, CR9 operating satisfactorily?	131	136
131	Is E_{cm} more negative than -.2V?	132	137
132	Analyze constant current generator Q9, correct faults and return to No. 131.	-	-
133	Refer to Section IV for theory of operation and go to No. 127.	-	-
134	Analyze R12, R13, Q6, correct faults and return to No. 128.	-	-
135	Analyze Q10 and associated resistors, correct faults and return to No. 129	-	-

Step No.	Procedure	If YES, Go to Number	If NO, Go to Number
136	Analyze Q12, CR8, CR9, correct faults and return to No. 130.	-	-
137	Is E_{cm} more positive than +0.05V?	138	127
138	Analyze constant current generator Q11, correct fault and return to No. 131.	-	-

6-4. PIN CHART

The following chart shows the various logic elements as designated in the theory of operation and in the schematics, together with the board on which each element is located. The third column shows the pin upon which the "true/false" output appears, while the fourth column shows the pin on which the NOT output (when this is utilized) is found.

Logic Designator	Board	True/False Output Location	Location of NOT Side
M_1	DIG	Z1 PIN 6	Z1 PIN 7
M_2	DIG	Z7 PIN 6	Z7 PIN 7
M_3	ANA	Z5 PIN 6	
M_4	DIG	Z11 PIN 7	Z11 PIN 6
L_o	DIG	Z3 PIN 7	Z3 PIN 6
L_i	DIG	Z2 PIN 7	Z2 PIN 6
L_P	DIG	Z8 PIN 7	Z8 PIN 6
L_R	DIG	Z9 PIN 5	Z9 PIN 7
L_z	ANA	Z3 PIN 6	Z4 PIN 6
$R2^0$	ANA	J1 PIN H	
$R2^1$	ANA	J1 PIN E	
$R2^2$	ANA	J1 PIN F	

6-5. NORMAL POWER SUPPLY VOLTAGES AND LOAD RESISTANCES

Nominal Voltage	Actual Voltage	Load Resistance (Analog Bd.)	Load Resistance (Digital Bd.)
+32V	+34 ±5V	>10K ohms	>50K ohms
-32V	-34 ±5V	>10K ohms	>50K ohms
+24V	+24 ±1.5V	> 5K ohms	---
-24V	-24 ±1.5V	> 5K ohms	>15K ohms
+15V	+15 ±1.0V	>20K ohms	---
-15V	-15 ±1.0V	>20K ohms	---
+4V (-20 to -24)	+4 ±.4V	>150 ohms	>12 ohms
+190V	+170V ±20V		>50K ohms
+6.2V reference	+6.2V ±5%		---

NOTE: Load resistances should be measured with the power off and the analog board pulled out of the meter. All load resistances should be measured with respect to ground except +4V which is measured with respect to -24V. The ohmmeter terminal must have the same polarity as the power supply being measured. These measurements are to be made with an ohmmeter having a 1.5V voltage source.

6-6. HOLD CONDITION CHECKOUT CHART

NOTE: The hold condition is set by turning sample rate control fully clockwise.

Logic Level	Logic State or Voltage	Step No.
S.R.G. (Q1)	0	35
M_1	0	36
L_1	0	8
L_o	0	8
$M_1 + M_2$	0	37
M_2	0	38
L_R	0	8
D1 (Q25)	-24V	8
D2 (Q26)	+24V	8
D3 (Q27)	+24V	8
D4 (Q28)	-24V	8
D5 (Q29)	+24V	8
D7 (Q30)	-24V	8
M_3	0	39
M_4	0	40

Analog Test Pin	Voltage	Step No.
10V Ref.	-10V	52
Buffer Output (E_B)	0V ±1V	133
Integrator Out (E_I)	-.5V ±.1V	46
Zero Amp Out (E_Z)	-13V ±5V	46
Auto-Zero (E_C)	0V ±20V	*

*See Section IV, Paragraph 4-1-1, analyze auto-zero.

SECTION VII

PARTS LISTS AND SCHEMATICS

7-1. INTRODUCTION

The parts lists in this manual are set up in individual sections for the sake of clarity. Paragraph 7-2 contains the parts used in the basic DS-100 meter, including all parts which are common to all of the models in the K and P Series. It is subdivided into the chassis assembly, analog board assembly, reference board assembly, and digital board group assembly. Paragraph 7-3 includes the parts, other than common parts, which are used in each individual model in the K and P Series. Paragraph 7-4 includes the parts, other than common parts, which are used in each individual option (B, C, S3-1, W, X, etc.). Paragraph 7-5 includes the schematics and logic diagrams for the Doric DS-100 Series.

7-2. BASIC DS-100 PARTS LIST

(PARTS COMMON TO ALL K AND P MODELS)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-628-05, 100-625-06	DS-100 Basic Chassis Assembly						
	Side Rail, Right	Doric	100-205-05	100-205-05	1		
	Side Rail, Left	Doric	100-206-05	100-206-05	1		
	Bail Set, Complete with feet	Buckeye Stamping	7" w/feet	991-055-01	1		
	Front Bezel	Doric	100-203-04	100-203-04	1		
	Cover, Top	Doric	100-207-00	100-207-00	1		
	Shield, Reference	Doric	100-223-06	100-223-06	1		
	Binding Post, White	Pomona	2382-9	973-300-03	1	1	2.31
	Binding Post, Red	Pomona	2382-2	973-300-02	1	1	2.31
	Binding Post, Black	Pomona	2382-0	973-300-01	1	1	2.31
	Shield, Bottom	Doric	100-214-03	100-214-03	1		
	Lock, Nylon	Doric	100-249-02	100-249-02	1		
	Spring, Lock	Doric	100-219-04	100-219-04	1		
	Cover, Bottom	Doric	100-208-00	100-208-00	1		
	Lever, Bottom	Doric	100-218-02	100-218-02	1		
	Slider Bracket	Doric	100-212-02	100-212-02	1		
	Slider Strip	Doric	100-213-00	100-213-00	2		
	Spring, Plunger	Doric	100-243-00	100-243-00	2		
	Spacer, Plunger 1/4 x 2-1/2	H. H. Smith	8352	991-020-22	2		
J1, 2	Connector, Interconnecting	Cinch	251-22-30-341	973-010-08	2		
J4	Connector, 2 pin	Winchester	JF2P2S	973-020-01	1		
T1	Power Transformer	Aztec	10344	100-701-05	1		
	Connector Mounting Bracket	Doric	100-211-06	100-211-06	1		
	Bezel, Rear	Doric	100-204-07	100-204-07	1		
	Handle, Carrying	National Lock	C244-26D	991-050-01	1		
	Clamp, Heyco	H. H. Smith	939	991-056-20	1		
J3	Power Cord	Belden	17237B	993-200-01	1		
F1	Fuse, Power 1/4A, Slo-Blo	Littlefuse	313.250	971-010-01	1	2	.42

BASIC CHASSIS ASSEMBLY (Sheet 2 of 2)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	Fuse, Holder	Littlefuse	342004A	971-080-01	1		
	Filler Panel	Doric	100-215-00	100-215-00	1		
	Input Plug, Single	Pomona	2944	973-200-01	1		
	Input Plug, Dual	Pomona	2244	973-200-02	1		
	Insert Panel	Doric	100-269-00	100-269-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-625-XX	Analog Board Assembly						
	Circuit Board, Analog	Doric	100-225-10	100-225-10	1		
Z1	Integrated Circuit, 741 Op Amp	Fairchild	741	965-506-00	1	1	
Z3,4,5	Integrated Circuit, CμL	Fairchild	91428-751	965-500-00	3	1	2.16
Q17,18,23, 24	Transistor, FET - High Leakage	Amelco	U1742	100-722-00	4	1	2.40
Q3-5	Transistor, FET-Low Leakage	Amelco	U1742	100-732-00	3	1	3.60
Q6A,6B	Transistor, Dual	Amelco	SU2211	100-724-00	1	1	13.50
Q7,8,12, 15,19,21, 48	Transistor, 2N4250	National SC	2N4250	962-425-00	7	1	1.60
Q9,44	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	2	1	1.12
Q16	Transistor, 2N3567	Fairchild	F2N3567814	962-356-70	1	1	1.24
Q11,22, 25-30	Transistor, 2N3877A	G. E.	2N3877A	962-387-11	8	1	1.20
Q10,13,14 20,45,47	Transistor, 2N3393	G. E.	2N3393	962-339-30	6	1	.72
Q49	Transistor, 40406	RCA	40406	964-040-02	1	1	3.48
Q46	Transistor, 40347	RCA	40347	964-040-00	1	1	1.92
CR1-5,10, 11,13-17 35-40	Diode, 1N914	Continental Devices	1N914	961-091-40	18	4	.50
CR6-9	Diode, Zener, 6.2V	Continental	1N753A	961-075-31	4	1	1.20
CR41,42	Diode, Zener, 24V	Continental Devices	1N970B	961-097-02	2	1	1.20
C2	Capacitor, .068μFD, 10%, Polystyrene	Elpac	PD5A683K	913-036-83	1		
C4	Capacitor, .068μFD, 10%, Polycarb	Elpac	B1A683J	911-036-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C6	Capacitor, .0047μF, 10%, Mylar	Elpac	ZD5A472J	912-074-72	1		
C7,8,19, 21,22, 24-26	Capacitor, 100PF, 10%, Disc	RMC	JL100X5F	901-011-01	8		
C5,20	Capacitor, .001μFD, 20%, Disc	RMC	BA.001Y5U	900-081-03	2		
C3,9,11, 14,16,18, 27-30	Capacitor, .01μFD, 20%, Disc	RMC	TA.01Y5U	900-021-04	10		
C12,1	Capacitor, .22μFD, 10%, Polystyrene	Elpac	PD5A224K	913-042-24	2		
C17	Capacitor, .22μFD, 10%, Polycarb	Elpac	B1A224J	911-032-24	1		
R83	Resistor, Metal Film, 1%, 56.2Ω	Corning	RN60D Series	920-356-29	1		
R123,124	Resistor, Metal Film, 1%, 215Ω	Corning	RN60D Series	920-321-50	2		
R82	Resistor, Metal Film, 1%, 511Ω	Corning	RN60D Series	920-351-10	1		
R79,81	Resistor, Metal Film, 1%, 5.11K	Corning	RN60D Series	920-351-11	2		
R126,127	Resistor, Metal Film, 1%, 8.25K	Corning	RN60D Series	920-382-51	2		
R80	Resistor, Metal Film, 1%, 51.1K	Corning	RN60D Series	920-351-12	1		
R16,25	Resistor, Metal Film, 1%, 68.1K	Corning	RN60D Series	920-368-12	2		
R119	Resistor, Metal Film, 1%, 178K	Corning	RN60D Series	920-317-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R41	Resistor, Metal Film, 1%, 619K	Corning	RN60D Series	920-361-93	1		
R19, 39, 42, 122	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	4	1	1.00
R11	Resistor, 1/2W, 5% Carbon, 4.7Ω	Allen-Bradley	EB47G5	942-304-79	1		
R29	Resistor, 1/4W, 5% Carbon, 47Ω	Allen-Bradley	CB4705	942-204-70	1		
R61, 108, 115	Resistor, 1/4W, 5% Carbon, 68Ω	Allen-Bradley	CB6805	942-206-80	3		
R51, 106, 107	Resistor, 1/4W, 5% Carbon, 110Ω	Allen-Bradley	CB1115	942-201-11	3		
R37, 38,	Resistor, 1/4W, 5% Carbon, 150Ω	Allen-Bradley	CB1515	942-201-51	2		
R49, 130	Resistor, 1/4W, 5% Carbon, 390Ω	Allen-Bradley	CB3915	942-203-91	2		
R30	Resistor, 1/4W, 5% Carbon, 470Ω	Allen-Bradley	CB4715	942-204-71	1		
R24, 27, 34, 55, 58, 62, 128	Resistor, 1/4W, 5% Carbon, 1K	Allen-Bradley	CB1025	942-201-02	7		
R57	Resistor, 1/4W, 5% Carbon, 1.2K	Allen-Bradley	CB1225	942-201-22	1		
R22	Resistor, 1/4W, 5% Carbon, 1.5K	Allen-Bradley	CB1525	942-201-52	1		
R20, 44, 66	Resistor, 1/4W, 5% Carbon, 2.2K	Allen-Bradley	CB2225	942-202-22	4		
R15	Resistor, 1/4W, 5% Carbon, 3.3K	Allen-Bradley	CB3325	942-203-32	1		
R56	Resistor, 1/4W, 5% Carbon, 6.2K	Allen-Bradley	CB6225	942-206-22	1		
R17, 60, 109, 113	Resistor, 1/4W, 5% Carbon, 4.7K	Allen-Bradley	CB4725	942-204-72	4		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R26,32,54 67,69,72, 74,77,111, 112,129	Resistor, 1/4W, 5% Carbon, 10K	Allen-Bradley	CB1035	942-201-03	11		
R31,35, 104,105	Resistor, 1/4W, 5% Carbon, 12K	Allen-Bradley	CB1235	942-201-23	4		
R18	Resistor, 1/4W, 5% Carbon, 15K	Allen-Bradley	CB1535	942-201-53	1		
R9,10,21,23 50,52,75	Resistor, 1/4W, 5% Carbon, 22K	Allen-Bradley	CB2235	942-202-23	6		
R33,36	Resistor, 1/4W, 5% Carbon, 39K	Allen-Bradley	CB3935	942-203-93	2		
R43,47,53 59,65, 102,103	Resistor, 1/4W, 5% Carbon, 47K	Allen-Bradley	CB4735	942-204-73	7		
R125,28	Resistor, 1/4W, 5% Carbon, 68K	Allen-Bradley	CB6835	942-206-83	2		
R48	Resistor, 1/4W, 5% Carbon, 100K	Allen-Bradley	CB1045	942-201-04	1		
R12,14, 64,118	Resistor, 1/4W, 5% Carbon, 220K	Allen-Bradley	CB2245	942-202-24	4		
R6-8,68 70,73, 78,85	Resistor, 1/4W, 5% Carbon, 330K	Allen-Bradley	CB3345	942-203-34	8		
R84	Resistor, 1/4W, 5% Carbon, 390K	Allen-Bradley	CB3945	942-203-94	1		
R71	Resistor, 1/4W, 5% Carbon, 470K	Allen-Bradley	CB4745	942-204-74	1		
R40,45	Resistor, 1/4W, 5% Carbon, 1.5M	Allen-Bradley	CB1555	942-201-55	2		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R63	Resistor, 1/4W, 5% Carbon, 3.3M	Allen-Bradley	CB3355	942-203-35	1		
	Thermal Link	Wakefield	259.1	992-010-01	1		
	Heatsink	Thermalloy	2211B	991-001-01	2		
	Transipad	Thermalloy	7717-3N	992-010-50	2		
CR45	Diode, IN457	Continental Devices	IN457	961-045-70	1		
R5	Resistor, 1/2W, 5% Carbon, 75K	Allen-Bradley	EB7535	942-307-53	1		
R4	Resistor, 1/2W, 5% Carbon, 24K	Allen-Bradley	EB2435	942-302-43	1		
R110,114	Resistor, 1/4W, 5% Carbon, 220Ω	Allen-Bradley	CB2215	942-202-21	2		
DS-1	Indicator, Neon	General Electric	NE-ZE	968-010-03	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-626-XX	Reference Board Assembly						
	Circuit Board, Reference	Doric	100-226-09	100-226-09	1		
Z1	Integrated Circuit	Fairchild	741	965-506-00	1		
Q3,4	Transistor, FET, High Leakage	Amelco	U1742	100-722-00	2	1	2.40
Q1	Transistor, 2N4250	National SC	2N42506743	962-425-00	1	1	1.60
Q2	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
CR1	Diode, Zener, Special	Doric	100-721-01	100-721-01	1		
CR4	Diode, Zener, 6.2V	Transistron	1N753A	961-075-31	1		
CR2,5,6, 7,17	Diode	Cont. Device	1N914	961-091-40	5	2	.50
C2	Capacitor, 22 PF, 10% Disc	RMC	22NPO	901-012-20	1		
C3	Capacitor, .001μFD, 20% Disc	RMC	BA .001Y5U	900-081-03	1		
R28	Resistor, WW, .05%, 49.995K	Mektron	Series C4	934-214-93	1		
R30	Resistor, WW, .05%, 4985.5Ω	Mektron	Series C4	934-214-92	1		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R57	Resistor, WW, .05%, 40K	Mektron	Series C4	934-214-03	1		
R15	Resistor, WW, .05%, 39.9K	Mektron	Series C4	934-213-94	1		
R8,13	Resistor, WW, .05%, 20K	Mektron	Series C4	934-212-03	2		
R5	Resistor, Metal Film, 1.78K, 1%	Corning	RN60C Series	920-417-81	1		
R1,2,3	Resistor, SOT, Metal Film	Corning	RN60D Series	---	3		
R6	Resistor, SOT, Metal Film	Corning	RN60C Series	---	1		
R10,24,26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	3		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R56	Resistor, Metal Film, 1K, 1%	Corning	RN60D Series	920-310-01	1		
R32	Resistor, Carbon, 1/4W, 5%, 1.5K	Allen-Bradley	CB1525	942-201-52	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R4,20	Resistor, Carbon, 1/4W, 5%, 8.2K	Allen-Bradley	CB8225	942-208-22	2		
R14	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	1		
R11,27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	2		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R12,23,44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	3		
R9	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R29,31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R16,22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	2		
R7	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1		
R17,25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	2		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-628-XX	Digital Board Group Assembly						
	Circuit Board, Digital	Doric	100-228-08	100-228-08	1		
Z14,17, 20,23	Integrated Circuit, CμL821	Fairchild	995879	965-501-01	4	1	11.20
Z15,18,21, 24	Integrated Circuit, CμL820	Fairchild	995979	965-501-02	4	1	10.05
Z16,19, 22,25	Integrated Circuit, CμL817	Fairchild	996079	965-501-03	4	1	15.70
Z8,9,26, 27	Integrated Circuit, CμL	Fairchild	92328-751	965-500-09	4	1	4.02
Z1-7, 10-13	Integrated Circuit, CμL	Fairchild	91428-751	965-500-00	11		
Q10-12, 14,19	Transistor, 2N3877A	G. E.	2N3877A	962-387-71	5		
Q17	Transistor, 2N3567	Fairchild	F2N3567814	962-356-70	1		
Q15	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
Q1-7,9,13,16	Transistor, 2N3393	G. E.	2N3393	962-339-30	10		
Q8	Transistor, 2N3606	G. E.	2N3606	962-360-60	1		
Q18	Transistor, 2N5296	RCA	2N5296	962-529-60	1	1	3.96
CR10-12	Diode, 1N914	Cont. Device	1N914	961-091-40	3		
CR2-9	Rectifier, SCE-2	Semtech	6824	966-002-00	8	1	1.20
CR1	Rectifier, SCE-6	Semtech	6812	966-002-04	1	1	1.62
C3,14	Capacitor, .22μFD, 10%, Polycarb.	Elpac	B1A224J	911-032-24	2		
Q5,31,12,18	Capacitor, .01μFD, 20%, Disc	RMC	TA.01Y5U	900-021-04	4		
C2,6,7, 13,15	Capacitor, .001μFD, 20%, Disc	RMC	BA.001Y5U	900-081-03	5		
C4,19,20,23	Capacitor, 100 PF, 10%, Disc	RMC	JL100X5F	901-011-01	4		
C16	Capacitor, 330 PF 10%, Disc	RMC	JL330X5F	901-013-31	1		
C17	Capacitor, .068μFD, 5% Polycarb.	Elpac	B1A683J	911-036-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C29	Capacitor, 5000μFD @10V, Electrolytic	Sprague	39D508G010-HP4	910-025-09	1	1	2.82
C27,28	Capacitor, 1100μFD @50V, Electrolytic	Sprague	39D118G050-HP4	910-041-18	2	1	2.82
C26	Capacitor, 100μFD @250V, Electrolytic	Sprague	39D107F250-HL4	910-061-07	1	1	2.79
C1	Capacitor, 25μFD @6V, Electrolytic	Sprague	30D256G006-BB2	910-032-56	1	1	1.00
C8,9,10	Capacitor,.01μFD, 10% Polycarb	Elpac	B5A103K	911-031-04	3	1	1.95
R64	Resistor, Carbon, 1/2W, 5% 15Ω	Allen-Bradley	EB1505	942-301-50	1		
R52-55	Resistor, Carbon, 1/2W, 5% 15K	Allen-Bradley	EB1535	942-302-23	4		
R57	Resistor, Carbon, 1/2W, 5%, 39K	Allen-Bradley	EB3935	942-303-93	1		
R56	Resistor, Carbon, 1/2W, 5%, 47K	Allen-Bradley	EB4735	942-304-73	1		
R24	Resistor, Carbon, 1/4W, 5%, 390Ω	Allen-Bradley	CB3915	942-203-91	1		
R43	Resistor, Carbon, 1/4W, 5%, 470Ω	Allen-Bradley	CB4715	942-204-71	1		
R25	Resistor, Carbon, 1/4W, 5%, 680Ω	Allen-Bradley	CB6815	942-206-81	1		
R46,47,48,51, 8,28,33,34 41	Resistor, Carbon, 1/4W, 5%, 1K	Allen-Bradley	CB1025	942-201-02	9		
R20	Resistor, Carbon, 1/4W, 5%, 1.2K	Allen-Bradley	CB1225	942-201-22	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R30,31, 32	Resistor, Carbon, 1/4W, 5%, 1.5K	Allen-Bradley	CB1525	942-201-52	3		
R67	Resistor, Carbon, 1/4W, 5%, 1.8K	Allen-Bradley	CB1825	942-201-82	1		
R22,27,66	Resistor, Carbon, 1/4W, 5%, 2.2K	Allen-Bradley	CB2225	942-202-22	3		
R21	Resistor, Carbon, 1/4W, 5%, 3.3K	Allen-Bradley	CB3325	942-203-32	1		
R13,17-19, 23,26,29 36,37,42, 59,63,65, 70,71,75	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	16		
R4,5,12, 15,16,69, 81,82	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	8		
R7,11,62	Resistor, Carbon, 1/4W, 5%, 15K	Allen-Bradley	CB7535	942-207-53	3		
R2,39,60, 73,77,80,6	Resistor, Carbon, 1/4W, 5%, 47K	Allen-Bradley	CB4735	942-204-73	7		
R3,79	Resistor, Carbon, 1/4W, 5%, 75K	Allen-Bradley	CB7535	942-207-53	2		
R14,40, 61,74,78	Resistor, Carbon, 1/4W, 5%, 150K	Allen-Bradley	CB1545	942-201-54	5		
R1,35,38, 58,72,76	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	6		
R68	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
F2	Fuse, 1 amp, Pigtail 3AGSBPT	Littlefuse	315001	971-060-01	1	1	.69
L1	Choke, 240μh	Delvin	1537-94	967-005-01	1		
	Socket, Nixie	Burroughs	SK-196	992-001-01	4		
V1,2,3,4	Indicators, Nixie	Burroughs	B5441A	968-050-01	4	1	11.00
	Heatsink	Doric	100-227-02	100-227-02	1		
	Doric Logo	Doric	100-251-00	100-251-00	1		
	Knob, Power/Sample Rate	Doric	100-221-03	100-221-03	1		
	Symbol Board	Doric	100-242-04	100-242-04	1		
DS1-8	Neon Indicators	G. E.	NE-2H	968-010-01	8	1	.45
	Symbol Block	Doric	100-217-01	100-217-01	1		
	Mounting Bracket, Switch	Doric	100-216-02	100-216-02	1		
	Front Panel, Upper	Doric	100-209-02	100-209-02	1		
	Symbol Film	Doric	100-240-02	100-240-02	1		
S1	Switch, Power	Mallory	US26	969-100-01	1	1	1.60
R9	Potentiometer, Sample Rate, 100K	Mallory	U39	960-011-04	1	1	2.31
J5	Connector, 2 pin	Winchester	JF2P2S	973-020-01	1		
	Ringnut	Eldema	141-10003-010	991-030-01	1		
C32	Capacitor, Trim, 170PF to 780PF	Arco-Elmenco	469	914-100-00	1		
R-83	Resistor, 1/4W, 5%, Carbon, 110Ω .	Allen-Bradley	CB1115	942-201-11	1		

7-3. INDIVIDUAL PARTS

K AND P SERIES

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K1 Plug-in Single range, 10MV, F.S. Add:						
Schematic 100-625-XX	Front Panel, Lower	Doric	100-250-00	100-250-00	1 Add:		
Q6A, 6B	Transistor, Dual, Special (replaces P/N 100-724-00)	Doric	100-725-00	100-725-00	1 Replace: 1		58.80
R13	Pot, 1K	Beckman	79PR1K	960-011-02			
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-625-XX					Remove:		
R30	Resistor, WW, .05%, 4985.5Ω	Mektron	Series C4	934-214-92	1		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R24, 26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29, 31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		
	Add to Ref. Board Assembly:						
R35	Resistor, WW, .05%, 50.05Ω	Mektron	Series C4	934-215-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K2 Plug-in						
	Single Range 100MV, F.S.						
Schematic	Add:						
100-625-XX	Front Panel, Lower	Doric	100-250-00	100-250-00	1		
Q6A, 6B	Transistor, Dual FET	Doric	100-725-00	100-725-00	1		
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-625-XX					Remove:		
R30	Resistor, WW, .05%, 4985.5 Ω	Mektron	Series C4	934-214-92	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R24, 26	Resistor, Carbon, 1/4W, 5% 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29, 31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 259Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		
	Add to Ref. Board:						
R35	Resistor, WW, .05%, 505.00Ω	Mektron	Series C4	934-215-01	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K3 Plug-in Single Range, 1V, F.S. Add:						
Schematic 100-625-XX	Front Panel, Lower	Doric	100-250-00	100-250-00	Add: 1		
Q6A, 6B	Transistor, Dual FET	Doric	100-725-00	100-725-00	1		
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-626-05					Remove:		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R24, 26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R30	Resistor, WW, .05%, 4985.5Ω	Mektron	Series C4	934-214-92	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29, 31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		
	Add to Ref. Board:						
R35	Resistor, WW, .05%, 5.555K	Mektron	Series C4	934-215-52	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K4 Plug-in						
	Single Range 10V, F.S.						
Schematic	Add:				Add:		
100-625-XX	Front Panel, Lower	Doric	100-250-00	100-250-00	1		
Q6A, 6B	Transistor, Dual FET	Doric	100-725-00	100-725-00	1		
	The following parts are removed from the Reference Board Assembly:						
Schematic 100-625-XX					Remove:		
R28	Resistor, WW, .05%, 49.995K	Mektron	Series C4	934-214-93	1		
R30	Resistor, WW, .05%, 4985.5Ω	Mektron	Series C4	934-214-92	1		
R34	Resistor, WW, .05%, 499.45Ω	Mektron	Series C4	934-214-90	1		
R35	Resistor, WW, .05%, 55.555Ω	Mektron	Series C4	934-215-59	1		
R24, 26	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	2		
R33	Resistor, Carbon, 1/4W, 5%, 220Ω	Allen-Bradley	CB2215	942-202-21	1		
R27	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	1		
R21	Resistor, Carbon, 1/4W, 5%, 120K	Allen-Bradley	CB1245	942-201-24	1		
R23, 44	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	2		
R29, 31	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	2		
R22	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
R25	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001 AD1	960-015-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K5 Plug-in 4 range, 10MV-10V, F.S.						
Schematic 100-625-XX	Add to Analog Board Assembly:						
	Front Panel, Lower	Doric	100-247-00	100-247-00	1 Add:		
S3-6	Switch, 4-position, pushbutton	Centralab	2XCC000400-170	969-010-00	1 Add:		
Q6A, 6B	Transistor, Dual, Special (replace P/N100-724-00)	Doric	100-725-00	100-725-00	1	Replace: 1	58.80
R13	Pot, 1K	Beckman	79PR1K	960-011-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K5A Plug-in 4 Range, 1V-750V, F.S.						
Schematic 100-625-XX	Add to Analog Board Assembly:				Add:		
	Front Panel, Lower	Doric	100-246-00	100-246-00	1		
S1-4	Switch, 4-position, pushbutton	Centralab	2XCC000400-170	969-010-00	1		
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
Q6A, 6B	Transistor, Dual FET	Doric	100-725-00	100-725-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	K6 Plug-in 6 Range, 10MV-750V, F.S.						
Schematic 100-625-XX	Add to Analog Board Assembly:				Add:		
	Front Panel, Lower	Doric	100-210-03	100-210-03	1		
S1-6	Switch, 6 position, pushbutton	Centralab	2XCC000600-171	969-010-02	1		
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
Q6A, 6B	Transistor, Dual Special (replace P/N 100-724-00)	Doric	100-725-00	100-725-00	1	Replace 1	58.80
R13	Potentiometer, 1K	Beckman	79PR1K	960-011-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	P1 Plug-in 4 range, 1V-750V, F.S.						
Schematic 100-625-XX	Add to Analog Board Assembly:				Add:		
	Front Panel, Lower	Doric	100-246-00	100-246-00	1		
S1-4	Switch, 4 position, pushbutton	Centralab	2XCC000400-170	969-010-00	1		
	Transistor, Dual FET	Doric	100-725-00	100-725-00	1		
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
Z2	Integrated Circuit, CμL 817	Fairchild	996079	965-501-03	1		
Q31-38	Transistor, FET - High Leakage	Amelco	U1742	100-722-00	8		
Q43	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
Q39-42	Transistor, 2N3877A	G.E.	2N3877A	962-387-71	4		
CR18-26, 28, 29, 31-34	Diode, 1N914	Cont. Dev.	1N914	961-091-40	15		
R98-101	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	4		
R96-97	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	2		
R87	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R92-95	Resistor, Carbon, 1/4W, 5%, 470K	Allen-Bradley	CB4745	942-204-74	4		
R86, 88-90	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	4		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R91	Resistor, Carbon, 1/4W, 5%, 3.3 meg	Allen-Bradley	CB3355	942-203-35	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	P2 Plug-in 6 Range, 10MV-750V, F.S.						
Schematic 100-625-XX	Add to Analog Board Assembly:				Add:		
	Front Panel, Lower	Doric	100-210-03	100-210-03	1		
S1-6	Switch, 6 position, pushbutton	Centralab	2XCC000600-171	969-010-02	1		
R1	Resistor, Metal Film, .1%, 10 megΩ	I.R.C.	MEH T-9 Series	922-510-05	1		
K1	Relay, 24V	Parelco	R10-E595	970-001-01	1		
R2	Resistor, WW, .05%, 100.909K	Mektron	Series C4	934-211-03	1		
R3	Potentiometer, 250Ω	CTS	P115R251A	960-012-51	1		
Z2	Integrated Circuit, CμL 817	Fairchild	996079	965-501-03	1		
Q31-38	Transistor, FET - High Leakage	Amelco	U1742	100-722-00	8		
Q43	Transistor, 2N3638	Fairchild	F2N3638732	962-363-80	1		
Q39-42	Transistor, 2N3877A	G.E.	2N3877A	962-387-71	4		
CR18-26, 28, 29, 31-34	Diode, 1N914	Cont. Device	1N914	961-091-40	16		
R98-101	Resistor, Carbon, 1/4W, 5%, 4.7K	Allen-Bradley	CB4725	942-204-72	4		
R96,97	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	2		
R87	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R92-95	Resistor, Carbon, 1/4W, 5%, 470K	Allen-Bradley	CB4745	942-204-74	4		
R86,88-90	Resistor, Carbon, 1/4W, 5%, 1 meg	Allen-Bradley	CB1055	942-201-05	4		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
R91	Resistor, Carbon, 1/4W, 5%, 3.3 meg	Allen-Bradley	CB3355	942-203-35	1		
Q6A, 6B	Transistor, Dual Special (replaces P/N 100-724-00)	Doric	100-725-00	100-725-00	1	Replace: 1	58.80
R13	Pot, 1K	Beckman	79-PR1K	960-011-02	1		
C1	Capacitor, .1 mfd, Polystyrene			913-031-05	1		
C2	Capacitor, .033 mfd, Polystyrene			913-033-32	1		
	Remove:						
C1	Capacitor, .22 mfd, Polystyrene	IMB	PA2A224	913-042-24	1		
C2	Capacitor, .068 mfd, Polystyrene	Elpac	PD5A683	913-036-83	1		

7-4. OPTIONS

OPTION B - Self-Check (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	Option B - Self Check						
Schematic 100-625-06					Add:		
S-7	Switch, Toggle	Alco	MST-105F	969-010-40	1		
	Bracket, Self-Check	Doric	100-244-02	100-244-02	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-626-05	Option C - DC/DC Ratios The following parts are added to Reference Board Assembly 100-426.				Add:		
Z2	Integrated Circuit	Motorola	MC-1439G	965-504-00	1		
CR8,9,11, 13,14,18	Diode, 1N914	Cont. Dev.	1N914	961-091-40	6		
R43	Resistor, WW, .05%, 2.495K	Mektron	Series C4	934-212-43	1		
R46	Resistor, WW, .05%, 2.855K	Mektron	Series C4	934-212-82	1		
R36	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	1		
R39	Resistor, Carbon, 1/4W, 5%, 8.2K	Allen-Bradley	CB8225	942-208-22	1		
R58	Resistor, Carbon, 1/4W, 5% 390Ω	Allen-Bradley	CB3915	942-203-91	1		
R38	Resistor, Carbon, 1/4W, 5% 470K	Allen-Bradley	CB4745	942-204-74	1		
R50	Resistor, Carbon, 1/4W, 5% 56K	Allen-Bradley	CB5635	942-205-63	1		
R42	Resistor, Carbon, 1/4W, 5% 100K	Allen-Bradley	CB1045	942-201-04	1		
R40	Resistor, Carbon, 1/4W, 5% 220K	Allen-Bradley	CB2245	942-202-24	1		
R49	Resistor, Carbon, 1/4W, 5% 1 meg	Allen-Bradley	CB1055	942-201-05	1		
R45	Potentiometer, 10Ω	CTS	P115R100A	960-011-00	1		
R37, 41, 51	Potentiometer, 5K, 4TR	Centralab	2ELAFK0001 AD1	960-015-02	3		
S1	Switch, Slider	Continental Wirt	G126	969-010-30	1		
C7	Capacitor, .002μFD, 20% Disc	RMC	BA .002Z5U	900-082-03	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
Schematic 100-625-06	Option E - High Speed Analog Board Assembly 100-425 - add the following:				Add:		
C15	Capacitor, 22PF, 10%, Disc	RMC	22NPO	901-012-20	1		
Schematic 100-625-06	The following components replace existing components on the Analog Board Assembly 100-425				Replace:		
C1	Capacitor, .01μF, Polystyrene (replaces P/N 913-042-24)	Elpac	PD5A103K	913-031-04	1		
C2	Capacitor, .001μF, 20%, Disc (replaces P/N 913-036-83)	RMC	BA.001Y5U	900-081-03	1		
C17	Capacitor, .068μF, Polycarb. (replaces P/N 911-032-24)	Elpac	B1A683J	911-036-83	1		
R41	Resistor, Metal Film, 1%,100K (replaces P/N 920-361-93)	Corning	RN60D Series	920-310-03	1		
R64	Resistor, Carbon, 1/4W, 5%, 22K (replaces P/N942-202-24)	Allen-Bradley	CB2235	942-202-23	1		
R76	Resistor, Carbon, 1/4W, 5%, 47K (replaces P/N942-201-24)	Allen-Bradley	CB4735	942-204-73	1		
Schematic 100-628-05	The following components replace existing components on the Digital Board Assembly 100-428						
Q8	Transistor, 2N3606 (replaces P/N 962-387-71)	G.E.	2N3606	962-360-60	1	1	.84
C1	Capacitor, Electrolytic, 3MFD @25V (replaces P/N 910-032-56)	Sprague	30D.TE1201.1	910-030-36	1		
C10	Capacitor, 330PF, 10%, Disc (replaces P/N 911-031-04)	RMC	JL330X5F	901-013-31	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
C16	Capacitor, 100PF, 10%, Disc (replaces P/N 901-013-31)	RMC	JL100X5F	901-011-01	1		
R21	Resistor, Carbon, 1/4W, 5%, 1K (replaces P/N942-203-32)	Allen-Bradley	CB1025	942-201-02	1		
R14	Resistor, Carbon, 1/4W, 5% 4.7K (replaces P/N942-201-54)	Allen-	CB4725	942-204-72	1		
	Remove the following:				Remove:		
C8	Capacitor, .01μFD, Polycarbonate, 10%	Elpac	B5A103K	911-031-04	1		
C32	Capacitor, Trim, 170-780PF	Arco-Elmenco	469	914-100-00	1		
	Add the following:				Add:		
XTAL 1	Crystal, 600KC	Texas Crystals	TC-6	100-781-00	1	1	15.75
	Crystal Holder	Augat	8000-AG-6	992-010-00	1		

OPTION W - RACK ADAPTER (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	Option W-Rack Adapter						
	Filler Panel	Doric	100-235-01	100-235-01	1		
	Support Bar, Front	Doric	100-232-00	100-232-00	1		
	Support Bar, Rear	Doric	100-231-00	100-231-00	1		
	Rack Mtg Bracket, Right	Doric	100-234-01	100-234-01	1		
	Rack Mtg Bracket, Left	Doric	100-233-01	100-233-01	1		

OPTION X - EXTENDER BOARD (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	OPTION X, Extender Board						
	Circuit Board, extender	Doric	100-241-00	100-241-00	1		
	Connector	Cinch	251-22-30-341	973-010-08	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	OPTION Y Rear Signal Inputs In Basic Chassis Assembly:				ADD:		
	Binding Post, White	Pomona	2382-9	973-300-03	1		
	Binding Post, Red	Pomona	2382-2	973-300-02	1		
	Binding Post, Black	Pomona	2382-0	973-300-01	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part Number	Qty/ Assy.	Rec. Spare	Unit Price
	OPTION Z-Signal Input cord set, low thermal						
	In Basic Chassis Assembly						
	REMOVE:				Remove:		
	Input plug, single	Pomona	2944	973-200-01	1		
	Input plug, dual	Pomona	2244	973-200-02	1		
	ADD:				ADD:		
	Special Low Thermal Signal Input Cord Set	Pomona	100-711-00 Doric Spec.	100-711-00	1		

OPTION Z - INPUT CABLE (Sheet 1 of 1)

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
Schematic 100-636-XX	Option S4-1 Input/Output Board Assembly						
	Circuit Board, Input/Output	Doric	100-236-08	100-236-08	1		
Q2-1 thru 2-16, 2-18, 2-19, 10-1 thru 10-6, 4-1, 4-2, 4-3, 5-1, 5-2, 5-3, 8, 13, 15-17, 19-21	Transistor, 2N3393	General Electric	2N3393	962-339-30	37		
Q3-1, 3-2, 3-3, 11, 12, 14	Transistor, 2N3415	General Electric	2N3415	962-341-50	6		
Q1-1 thru 1-16, 1-18, 1-19, 18, 7, 9-1 thru 9-6	Transistor, FET	Amelco	UR061E	100-729-00	26	1	2.40
	Transistor, 2N3567	Fairchild	F2N3567	962-356-70	2		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
CR1-1 thru 1-16, 1-18, 1-19, 2-1, 2-2, 2-3, 3-1, 3-2, 3-3, 4-1, 4-2, 4-3, 6-1, 7-1, 8-1 thru 8-6, 9-12, 14 thru 24, 5-1, 5-2, 5-3	Diode, 1N914	Continental Device	1N914	961-091-40	55		
CR13	Diode, 1N753A	Continental Device	1N753A	961-075-31	1		
C1-1 thru 1-16, 1-18, 1-19, 4-1 thru 4-6, 3-1	Capacitor, 100 pf, 10%, Disc	RMC	JL100X5F	901-011-01	25		
C6, 7, 11	Capacitor, 220 pf, 10%, Disc	RMC	JL220X5F	901-012-21	3		
C2-1, 2-2, 2-3, 10	Capacitor, .002μfd, 20%, Disc	RMC	BA-002Z5U	900-082-03	4		
C-9, 13	Capacitor, .01 μ fd, 20%, Disc	RMC	TA.01Y5U	900-021-04	2		
C8	Capacitor, .068μ fd, Polycarbonate	Elpac	B1A683J	911-036-83	1		
C-12	Capacitor, .22μ fd, Polycarbonate	Elpac	B1A224J	911-032-24	1		
L1	Choke, 240μh	Delavin	1537-94	967-005-01	1		
R4-1 thru 4-16, 4-18, 4-19, 18-1, 18-2, 18-5, 18-6, 15-1, 11-1, 12-1	Resistor, Carbon, 1/4W, 5%, 330Ω	Allen-Bradley	CB3315	942-203-31	23		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
R44, 45	Resistor, Carbon, 1/4W, 5%, 470Ω	Allen-Bradley	CB4715	942-204-71	2		
R18-3, 4	Resistor, Carbon, 1/4W, 5%, 110Ω	"	CB1115	942-201-11	2		
R19	Resistor, Carbon, 1/4W, 5%, 1.5K	Allen-Bradley	CB1525	942-201-52	1		
R37, 23, 25	Resistor, Carbon, 1/4W, 5%, 2.2K	Allen-Bradley	CB2225	942-202-22	3		
R3-1 thru 3-16, 3-18, 3-19, 14-1, 10-1, 10-2, 10-3, 34	Resistor, Carbon, 1/4W, 5%, 3.3K	Allen-Bradley	CB3325	942-203-32	23		
R49, 20, 21, 32	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	4		
R9-1, 9-2, 9-3, 22, 24, 26, 28, 29, 35, 38, 46, 47, 48	Resistor, Carbon, 1/4W, 5%, 22K	Allen-Bradley	CB2235	942-202-23	13		
R39	Resistor, Carbon, 1/4W, 5%, 33K	Allen-Bradley	CB3335	942-203-33	1		
R1-1 thru 1-16, 1-18, 1-19, 5-1, 5-2, 5-3, 16-1, thru 16-6, 43	Resistor, Carbon, 1/4W, 5%, 47K	Allen-Bradley	CB4735	942-204-73	28		
R41	Resistor, Carbon, 1/4W, 5%, 68K	Allen-Bradley	CB6835	942-206-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
R6-1, 6-2, 6-3, 27, 33	Resistor, Carbon, 1/4W, 5%, 100K	Allen-Bradley	CB1045	942-201-04	5		
R7-1, 7-2, 7-3, 8-1, 8-2, 8-3, 30, 31, 36, 40	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	10		
R42	Resistor, Carbon, 1/4W, 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R2-1 thru 2-16, 2-18, 2-19, 17-1, thru 17-6, 13-1	Resistor, Carbon, 1/4W, 5%, 1 MEG	Allen-Bradley	CB1055	942-201-05	25		
T1-1 thru 1-16, 1-18, 1-19, 2-1, 2-2, 2-3, 3-1, 4-1 thru 4-6, 5, 6	Transformer, Guard Crossing	J.W. Miller	B6385	100-703-01	30		
J1	Connector, 31 pin	Winchester	PQD31S	973-021-01	1		
	Connector Hood	Doric	100-237-02	100-237-02	1		
	Jack Screw	AMP	5823603	991-040-00	2		
	Cable, Clamp and Tie	Panduit	SST-ITM-2	991-056-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
Schematic 100-636-04	Option S4-2 Input/Output Board Assembly						
	Circuit Board, Input/Output	Doric	100-236-05	100-236-05	1		
4-1, 4-2, 4-3, 5-1, 5-2, 5-3, 8, 13, 17, 19-21, 16	Transistor, 2N3393	General Electric	2N3393	962-339-30	13		
Q3-1, 3-2, 3-3, 11, 12, 14	Transistor, 2N3415	General Electric	2N3415	962-341-50	6		
Q18, 6, 7	Transistor, FET	Amelco	U1826E	100-723-00	3	1	2.40
CR2-1, 2-2, 2-3, 3-1, 3-2, 3-3, 4-1, 4-2, 4-3, 9-12, 14 thru 20, 5-1, 5-2, 5-3	Diode, 1N914	Continental Device	1N914	961-091-40	23		
CR13	Diode, 1N753A	Continental Device	1N753A	961-075-31	1		
C3-1	Capacitor, 100 pf, 10%, Disc	RMC	JL100X5F	901-011-01	1		
C6, 7, 11	Capacitor, 220 pf, 10%, Disc	RMC	JL220X5F	901-012-21	3		
C2-1, 2-2, 2-3, 10	Capacitor, .002μ fd, 20%, Disc	RMC	BA002Z5U	900-082-03	4		
C-9, 13	Capacitor, .01μ fd, 20%, Disc	RMC	TA.01Y5U	900-021-04	2		
C-8	Capacitor, .068μ fd, Polycarbonate	Elpac	B1A683J	911-036-83	1		
C-12	Capacitor, .22μ fd, Polycarbonate	Elpac	B1A224J	911-032-24	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
L1	Choke, 240 μ h	Delavin	1537-94	967-005-01	1		
R15-1	Resistor, Carbon, 1/4W, 5%, 330 Ω	Allen-Bradley	CB3315	942-203-31	1		
R19	Resistor, Carbon, 1/4W, 5%, 1.5K	Allen-Bradley	CB1525	942-201-52	1		
R37, 23, 25	Resistor, Carbon, 1/4W, 5%, 2.2K	Allen-Bradley	CB2225	942-202-22	3		
R14-1, 10-1, 10-2, 10-3, 34	Resistor, Carbon, 1/4W, 5%, 3.3K	Allen-Bradley	CB3325	942-203-32	5		
R49, 20, 21, 32	Resistor, Carbon, 1/4W, 5%, 10K	Allen-Bradley	CB1035	942-201-03	4		
R9-1, 9-2, 9-3, 22, 24, 26, 28, 29, 35, 38	Resistor, Carbon, 1/4W 5%, 22K	Allen-Bradley	CB2235	942-202-23	10		
R39	Resistor, Carbon, 1/4W, 5%, 33K	Allen-Bradley	CB3335	942-203-33	1		
R5-1, 5-2, 5-3, 43, 11-1, 12-1	Resistor, Carbon, 1/4W, 5%, 47K	Allen-Bradley	CB4735	942-204-73	6		
R41	Resistor, Carbon, 1/4W, 5%, 68K	Allen-Bradley	CB6835	942-206-83	1		
R6-1, 6-2, 6-3, 27, 33	Resistor, Carbon, 1/4W, 5%, 100K	Allen-Bradley	CB1045	942-201-04	5		

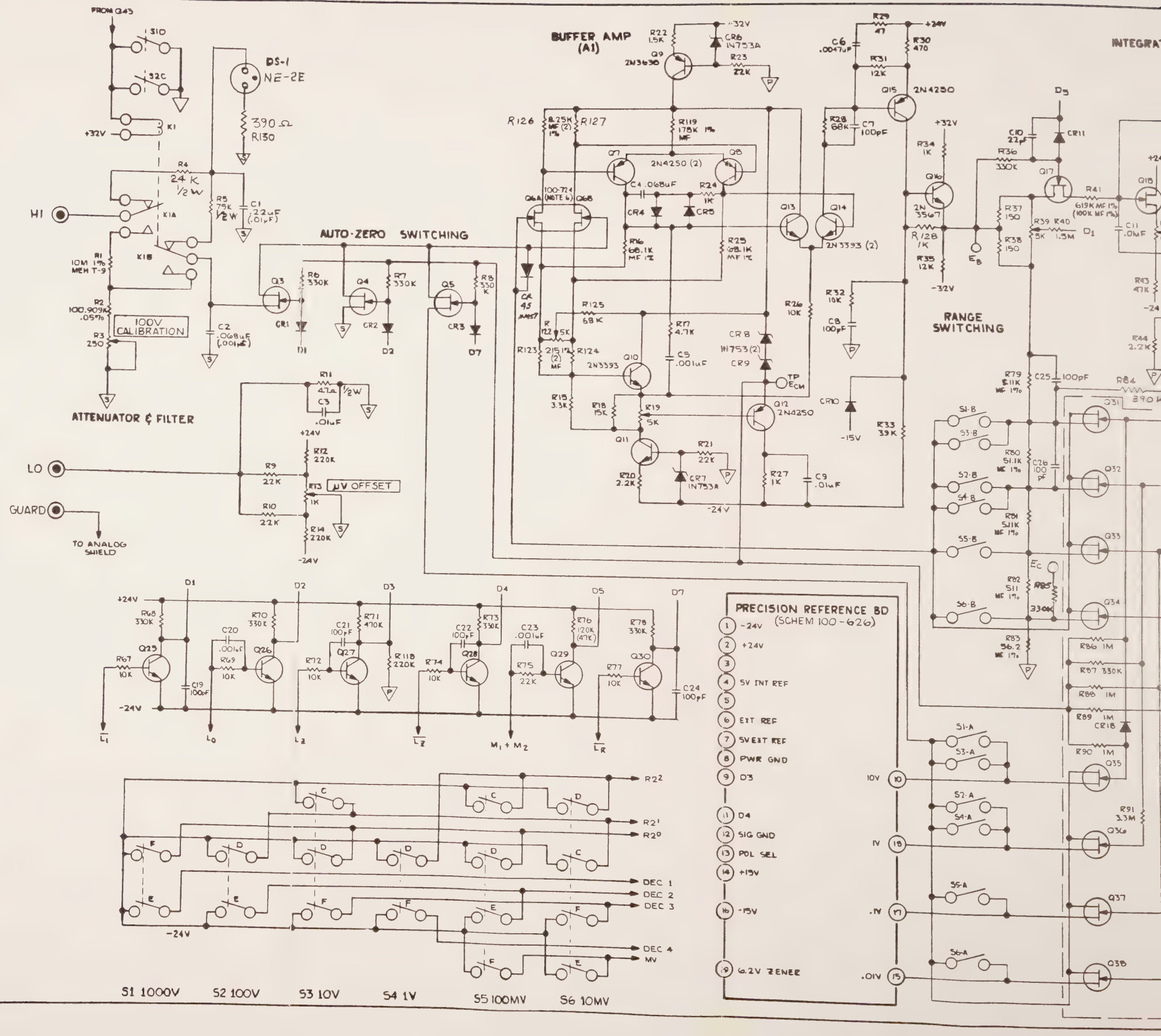
Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
R7-1, 7-2, 7-3, 8-1, 8-2, 8-3, 30, 31, 36, 40	Resistor, Carbon, 1/4W, 5%, 220K	Allen-Bradley	CB2245	942-202-24	10		
R42	Resistor, Carbon, 1/4W 5%, 330K	Allen-Bradley	CB3345	942-203-34	1		
R13	Resistor, Carbon, 1/4W, 5%, 1 MEG	Allen-Bradley	CD1055	942-201-05	1		
T2-1, 2-2, 2-3, 3-1, 5, 6	Transformer, Guard Crossing	J.W. Miller	B6385	100-703-01	6		
J1	Connector, 31 pin	Winchester	PQD315	973-021-01	1		
	Connector Hood	Doric	100-237-02	100-237-02	1		
	Jack Screw	AMP	5823603	991-040-00	2		
	Cable, Clamp and Tie	Panduit	SST-ITM-2	991-056-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	OPTION S-5, Analog Output Kit:						
Schematic 100-625-06	Add to Analog Board Assembly:						
CR46, 47	Diode, 1N457	Continental Devices	1N457	961-045-70	2		
CR43, 44	Diode, 1N753A	Continental Devices	1N753A	961-075-31	2		
C-31	Capacitor, .01 mfd, 20%, Disc	RMC	TA.01Y5U	900-021-04	1		
R-133	Resistor, Metal Film, 1%, 102Ω	Corning	RN60D Series	920-310-20	1		
R-135	Resistor, Metal Film, 1%, 10K	Corning	RN60C Series	920-410-02	1		
R-137	Resistor, 1/4W, 5%, Carbon, 100Ω	Allen-Bradley	CB1015	942-201-01	1		
R-136	Resistor, 1/4W, 5%, Carbon, 10K	Allen-Bradley	CB1035	942-201-03	1		
R-131	Resistor, 1/4W, 5%, Carbon, 47K	Allen-Bradley	CB4735	942-204-73	1		
R-134	Resistor, 1/4W, 5%, Carbon, 150K	Allen-Bradley	CB1545	942-201-54	1		
R-132	Resistor, 1/4W, 5%, Carbon, 1 MEG	Allen-Bradley	CB1055	942-201-05	1		
R-138	Potentiometer, 5K, 4TR	Centralab	ZELAFK0001AD1	962-015-02	1		
Z-2	OP AMP, Analog Output	Analog Devices	PB501B	965-505-00	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
Schematic 100-672-XX	Autorange Board Option	Doric	100-472-03	100-472-03	1		
	Integrated Circuit, Op Amp	Fairchild	741	965-506-00	3		
	Integrated Circuit	Motorola	MC717P	965-503-00	6		
	Transistor, 2N3373	GE	2N3393	962-339-30	4		
	Transistor, 2N3638	Fairchild	2N3638	962-363-80	1		
	Transistor, 2N3877A	GE	2N3877A	962-387-71	1		
	Transistor, 2N4250	National SC	2N4250	962-425-00	3		
	Transistor, FET	Amelco	U1742	100-732-00	4		
	Diode, 1N914	Cont. Dev.	1N914	961-091-40	34		
	Diode, 1N457	-	1N457	961-045-70	4		
	Diode, 1N753	Cont. Dev.	1N753	961-075-31	3		
	Resistor, mf, 1%, 40.2K	Corning	RN60C Series	920-440-22	1		
	Resistor, mf, 1%, 80.6K	Corning	RN60D Series	920-380-62	1		
	Resistor, mf, 1%, 97.6K	Corning	RN60D Series	920-397-62	1		
	Resistor, mf, 1%, 100K	Corning	RN60D Series	920-310-03	1		
	Resistor, mf, 1%, 422K	Corning	RN60D Series	920-342-23	1		
	Resistor, 1/4W, 5%, Carbon, 1K	Allen-Bradley	CB1025	942-201-02	3		
	Resistor, 1/4W, 5%, Carbon, 1.2K	Allen-Bradley	CB1225	942-201-22	1		
	Resistor, 1/4W, 5%, Carbon, 2.2K	Allen-Bradley	CB2225	942-202-22	13		
	Resistor, 1/4W, 5%, Carbon, 3.3K	Allen-Bradley	CB3325	942-203-32	3		
	Resistor, 1/4W, 5%, Carbon, 3.9K	Allen-Bradley	CB3925	942-203-92	1		
	Resistor, 1/4W, 5%, Carbon, 6.2K	Allen-Bradley	CB6225	942-206-22	2		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	Resistor, 1/4W, 5%, Carbon, 10K	Allen-Bradley	CB1035	942-201-03	13		
	Resistor, 1/4W, 5%, Carbon, 12K	Allen-Bradley	CB1235	942-201-23	1		
	Resistor, 1/4W, 5%, Carbon, 22K	Allen-Bradley	CB2235	942-202-23	4		
	Resistor, 1/4W, 5%, Carbon, 33K	Allen-Bradley	CB3335	942-203-33	6		
	Resistor, 1/4W, 5%, Carbon, 47K	Allen-Bradley	CB4735	942-204-73	2		
	Resistor, 1/4W, 5%, Carbon, 68K	Allen-Bradley	CB6835	942-206-83	2		
	Resistor, 1/4W, 5%, Carbon, 100K	Allen-Bradley	CB1045	942-201-04	1		
	Resistor, 1/4W, 5%, Carbon, 120K	Allen-Bradley	CB1245	942-201-24	1		
	Resistor, 1/4W, 5%, Carbon, 220K	Allen-Bradley	CB2245	942-202-29	3		
	Resistor, 1/4W, 5%, Carbon, 470K	Allen-Bradley	CB4745	942-204-74	5		
	Resistor, 1/4W, 5%, Carbon, 1 MEG	Allen-Bradley	CB1055	942-201-05	2		
	Resistor, 1/4W, 5%, Carbon, 1.5 MEG	Allen-Bradley	CB1555	942-201-55	1		
	Resistor, Variable, 5K, 4TR	Centralab	ZELAFK001AD1	960-015-02	7		
	Capacitor, .22 pf, disc	RMC	22NPO	901-012-20	1		
	Capacitor, .001 mfd, disc	RMC	BA .001Y5U	900-081-03	2		
	Capacitor, .01 mfd, disc	RMC	TA .01Y5U	900-021-04	7		
	Capacitor, .068 mfd, poly carb	Elpac	B1A 683J	911-036-83	1		

Ckt. Ref.	Description	Mfg.	Mfg. Part Number	Doric Part No.	Qty/ Assy	Rec. Spare	Unit Price
	Capacitor, .33 mfd	Elpac	B5A 334	911-033-34	1		
	Capacitor, .68 mfd	Elpac	B5A 684	911-036-84	1		
	Capacitor, 1 mfd	Elpac	B5A 105	911-031-06	1		
	Pins, Mating	Elco		973-080-01	25		


FROM Q43
S1D
S2C
DS-1
NE-2E
390 Ω
R130
+32V
K1
R4
24 K
½ W
HI
K1A
R5
79K
½ W
C1
.22uF
(.01uF)
K1B
R1
10M 1%
MEH T-9
R2
100.909K
.05%
R3
250
100V
CALIBRATION
C2
.068uF
(.001uF)
ATTENUATOR & FILTER
AUTO-ZERO SWITCHING
Q3
Q4
Q5
R6
330K
R7
330K
R8
330
K
CR1
CR2
CR3
D1
D2
D7
R11
4.7Ω
½W
C3
.01uF
+24V
R12
220K
LO
R9
22K
R13
1K
μV OFFSET
R10
22K
R14
220K
GUARD
TO ANALOG
SHIELD
-24V
BUFFER AMP
(A1)
R22
1.5K
Q9
2N3638
+32V
CR6
1N753A
R23
22K
P
R126
8.25K
MF (2)
1%
R127
R119
178K 1%
MF
Q7
Q8
2N4250 (2)
C4 .068uF
R24
1K
100-724
(NOTE 6)
Q6A
Q6B
CR4
CR5
R6
68.1K
MF 1%
R25
68.1K
MF 1%
CR
45
MIST
R125
68K
R
122
5K
R123
215 1%
(2)
MF
R124
2N3393
Q10
R17
4.7K
C5
.001uF
CR8
1N753 (2)
CR9
TP
ECM
R15
3.3K
R18
15K
R19
5K
Q11
R21
22K
CR7
1N753A
R20
2.2K
Q12
2N4250
R27
1K
C9
.01uF
-24V
R29
47
+24V
R30
470
C6
.0047uF
R31
12K
Q15
2N4250
R28
68K
C7
100pF
+32V
R34
1K
Q16
2N
3567
R128
1K
R35
12K
-32V
EB
Q13
Q14
2N3393 (2)
R32
10K
C8
100pF
R26
10K
CR10
-15V
R33
39K
INTEGRA
D3
C10
22pF
CR11
R36
330K
Q17
R41
619K MF 1%
(100K MF 1%)
Q18
R37
150
R39 R40
5K 1.5M
D1
C11
.01MF
R38
150
R43
47K
-24
RANGE
SWITCHING
R44
2.2K
R79
5.11K
MF 1%
C25 100pF
R84
390K
Q31
S1-B
S3-B
R80
5.11K
MF 1%
C26
100
pF
Q32
S2-B
S4-B
R81
5.11K
MF 1%
S5-B
Q33
EC
R82
511
MF 1%
R85
330K
S6-B
Q34
R83
36.2
MF 1%
P
R86 1M
R87 330K
R88 1M
R89 1M
CR18
R90 1M
Q35
S1-A
S3-A
S2-A
S4-A
R91
3.3M
Q36
S5-A
Q37
S6-A
Q38
D1
D2
D3
D4
D5
D7
+24V
R68
330K
C20
.001uF
R70
330K
C21
100pF
R71
470K
C22
100pF
R73
330K
C23
.001uF
R76
120K
(47K)
R78
330K
Q25
R67
10K
Q26
R69
10K
R72
10K
Q27
R118
220K
R74
10K
Q28
R75
22K
Q29
R77
10K
Q30
C19
100pF
C24
100pF
-24V
L1
L0
L2
L2
M1 + M2
LR
PRECISION REFERENCE BD
(SCHEM 100-626)
1 -24V
2 +24V
3
4 5V INT REF
5
6 EXT REF
7 5V EXT REF
8 PWR GND
9 D3
11 D4
12 SIG GND
13 POL SEL
14 +15V
16 -15V
19 6.2V ZENER
10V 10
1V 18
.1V 17
.01V 15
R22
R21
R20
C
D
E
F
DEC 1
DEC 2
DEC 3
DEC 4
MV
S1 1000V
S2 100V
S3 10V
S4 1V
S5 100MV
S6 10MV

ING AMP (A2)

ZERO CROSSING AMP

AUTO-ZERO AMP

ANALOG OUTPUT AMP

OPTION S5

ZERO SCHMITT TRIGGER

M3

RANGE DECODING

POWER SUPPLY REGULATORS

"P" MODELS

REFERENCE DESIGNATORS		
REF DES	LAST USED	DELETED (NOT TO BE REUSED)
R (RES)	R138	R116, R117
C (CAP)	C31	
CR (DIODE)	CR47	
Q (TRANS)	Q51	Q1, Q2

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL NPN TRANSISTORS ARE 2N3877A
2. ALL FETS ARE U1742.
3. ALL RESISTORS ARE ¼W 5% CARBON
4. ALL DIODES ARE IN914
5. (S) = SIGNAL GND (P) = POWER GND
6. 100-725 USED ON ALL METERS WITH 1uV/DIGIT SENSITIVITY.
7. C15 USED ON OPTION E ONLY. C1, C2, C17 AND R41, 64, 76 USE THE VALUES IN PARENTHESES FOR OPTION E.

DORIC SCIENTIFIC	ORIGINAL ISSUE	ANALOG SCHEMATIC
DYN-A-PAK	5-22-68	PART NONE
	5-29-68	TYPE SCHEMATIC
	5-29-68	SHT. 1 OF 1
		DWG NO. 100-625-06

J2

22 70V P-P } XFMR SECONDARY
21 9V P-P }
20 $\overline{L_2}$
19 -20V
18 CLOCK
17
16 $\overline{X_{13}}$
15 L_0
14 -24V
13 L_1 SET
12 PWR GND
11 DEC 1
10 DEC 2
9 DEC 3
8 DEC 4
7 $R2^0$
6 $R2^2$
5 $R2^1$
4
3
2
1 GUARD

CIRCUIT SIDE

Z 70V P-P } XFMR SECONDARY
Y 9V P-P }
X 380V P-P
W
V
U
T
S X_{83}
R L_1 RESET
P M_1
N $\overline{X_{11}}$
M LIN CLOCK
L $\overline{X_{12}}$
K +32V
J
H M_1+M_2
F $\overline{L_1}$
E $\overline{L_R}$
D -32V
C MV
B F_Y
A F_X

COMPONENT SIDE

SAMPLE RATE GENERATOR

-20V, R4 10K, R7 15K, R8 1K, R12 10K, C1 25uF (3uF), Q1, Q2, Q3, R9 100K, R10 SOT, R11 15K, R5 10K, R6 47K, R65 100K, -24V

CLOCK

C8 .01uF (Note 6), L1 240uH, XTAL, C10 .01uF (330pF), C11 SOT, R20 1.2K, C9 .01uF, 3 Z5A 6, 1 Z5B 7, C32 170 to 780 pF (Note 3)

CLOCK (J2-18)

CLOCK SYNC

LIN CLOCK (J

-20V, R31 1.5K, R32 1.5K, -24V

M_1

C2 .001uF, RMTE ENCODE, R13 4.7K, -24V, 2 Z1A 7, 5 Z1B 6, M_1, R14 150K (4.7K), R15 10K, C3 .22uF, C4 100pF, Q4, Q5, R16 10K, -20V, -24V

(J2-P)

M_1 & M_2 GATE

5 Z6A 6, 3, 2 Z6B 7, -20V, R22 2.2K, R21 (1K) 3.3K, C12 SOT, Q6, -24V

L_1

(J2-R) L_1 RESET, 1 Z2A 7, L_1

(J2-13) L_1 SET, 5 Z2B 6, 3, $\overline{L_1}$

(J2-F)

M_2

-24V, R23 4.7K, R24 390Ω, R25 680Ω, -20V, -20V, R28 1K, C13 .001uF, R26 4.7K, -24V, 1 Z7A 7, $\overline{M_2}$, C14 .22uF, 110 R83, C15 .001uF, R27 2.2K, Q7, -24V, 3 Z7B 6, M_2

RESET E.F.

POLARITY DR

-P
INDIC

+75V, R35 330K, Q10, R36 4.7K, 2N3877A

Z18B, PIN 2

L_P

$\overline{L_Z}$, 3, 5 $\overline{L_P}$, M_2, 2 Z8 J-K F.F., 1, 7 L_P, $\overline{L_Z}$

L_0

LR, 5, L_1, 3 Z3A 6, $\overline{L_0}$, -24V, 1K, 2, 1 Z3B 7, L_0, (J2-15), R17 4.7K, -24V, M_4 R41

(J2-E)

L_R

M_2, .01 C5, 10K R82, -24V, -20V, R29 4.7K, 6, 1, 7 $\overline{L_R}$, Z3A-5, 2 Z9 J-K F.F., 3, 5 L_R

DUAL DIFF

(J2-20) $\overline{L_Z}$, 5 Z4A 6, C7 .001uF, 2, 1 Z4B 7, C6 .001uF, R18 4.7K, R19 4.7K, -24V

M_4

L_0, R41 1K, -20V, R42 4.7K, C17 .068uF, C18 .01uF, -24V

INDICATOR NEONS

+75V, +190V, R1 330K, R2 47K, DS1, (J2-C), MV INDICATOR, R79 75K, P, DS2, +190V, R80 47K, (J2-A), F_X INDICATOR, DS3, (J2-B), RATIO INDICATOR, R3 75K, P

CLOCK GATE & BUFFER

Z10A 7 · Z10B 6 · C16 330pF (100pF)

RESET · CLOCK · HOLD

Z14 958 · Z17 958 · Z20 958 · Z23 958 — 12 · 7 -24V · 9 · 14 -20V · 2 3 4 5

Z15 959 · Z18 959 · Z21 959 · Z24 959 — 3 6 11 14 · 8 -24V · 16 -20V · 1 2 4 5 7 10 12 13 15

Z16 960 · Z19 960 · Z22 960 · Z25 960 — 14 15 7 6 · 8 -24V · 16 -20V · 9 5 10 4 11 3 12 2 13 1

$\overline{X_{80}}$ $\overline{X_{40}}$ $\overline{X_{20}}$ $\overline{X_{10}}$ · $\overline{X_{81}}$ $\overline{X_{41}}$ $\overline{X_{21}}$ $\overline{X_{11}}$ · $\overline{X_{82}}$ $\overline{X_{42}}$ $\overline{X_{22}}$ $\overline{X_{12}}$ · $\overline{X_{83}}$ $\overline{X_{43}}$ $\overline{X_{23}}$ $\overline{X_{13}}$

Y_{80} Y_{40} Y_{20} Y_{10} · Y_{81} Y_{41} Y_{21} Y_{11} · Y_{82} Y_{42} Y_{22} Y_{12} · Y_{83} Y_{43} Y_{23} Y_{13}

R46 1K → $\overline{X_{11}$ · C20 100 PF · -24

R47 1K → $\overline{X_{12}}$ · C19 100 PF · -24

R48 1K · R51 1K → $\overline{X_{13}}$ · C23 100 PF · -24

3 Z12B 6 · -24V · X_{83} (J2-S)

Z26 J-K F.F. · Z27 J-K F.F. — 1 2 3 6 7

X_{14} · $\overline{X_{14}}$ · Z12A PIN 2

+75V · R76 330K · Q19 2N3877A · -24V · R75 4.7K · FIFTH DIGIT "1" DS8 · +190V · R77 47K · R78 150K · P

T1 — BLK · WHT · (RED REPLACES WHT FOR 230V OPERATION) · RED · SHIELD · GRN (X) · BLU (Z) · VIO (12) · GRY (22) · WHT (NOT USED) · BLK (21) · BRN/WHT (Y) · RED/WHT · GUARD (J2-Z)

J3 · F1 3AG ¼A SB · J4 J5 · S1 (ON-OFF)

DEC 1 (J2-11) · DEC 2 (J2-10) · DEC 3 (J2-9) · DEC 4 (J2-8) — +190V

V1 · V2 · V3 · V4 — 0 1 2 3 4 5 6 7 8 9

R52 22K ½W · R53 22K ½W · R54 22K ½W · R55 22K ½W

M1 & M2 (J2-H)

-20V · Q9 · RESET · R34 1K · -24V

+190V · R39 47K · +POL INDICATOR · DS4 · +75V · DS5 · R38 330K · R40 150K · Q11 · R37 4.7K 2N3877A · -24V

R43 470 · 11A 7 · 5 Z11B 6

(J2-X) · CR1 SCE-6 · R56 47K · C26 100uF 250V · +190V · +75V · R57 39K ½W · +35 · (J2-K) · CR2 SCE-2 · CR3 SCE-2 · C27 1100uF 50V · (J2-Z) · (J2-22) · CR4 SCE-2 · CR5 SCE-2 · -35V · (J2-D) · C28 1100uF 50V · (J2-12)

CR6 SCE-2 · CR7 SCE-2 · (J2-Y) · (J2-21) · CR8 SCE-2 · CR9 SCE-2

C29 5000uF 10V · R62 15K · R61 10K · C30 50T · Q15 2N3638 · Q16 · CR10 · CR11 · R63 4.7K · R64 15Ω ½W · R65 4.7K · Q17 2N3567 · F2 1.0A · Q18 TA7156 · R66 2.2K · R67 1.8K · R68 5K · -17V · -20V · (J2-19) · -24V · (J2-14)

SAMPLE RATE NEON DRIVER — +75V · R58 330K · SAMPLE RATE · +190V · R60 47K · Q12 · R59 4.7K 2N3877A · D30 · P/O1 150K · -24V

OVERLOAD DETECTOR — X_{14} (Z26 PIN 1) · $\overline{X_{14}}$ (FROM Z26 PIN 5) · -20V · R69 10K · Q13 · CR12 · $\overline{X_{23}}$ · C33 .01uF · R64 47K · C31 .01uF · -24V · Z12A 7 · Z13A 6 · Z13B 7 · FROM Z28, PIN 6 · M_2 · R70 4.7K · -24V · +75V · R72 330K · OVERLOAD INDICATOR · DS7 · +190V · R73 47K · Q14 · R71 4.7K 2N3877A · -24V · R74 150K · P · L_{OL}

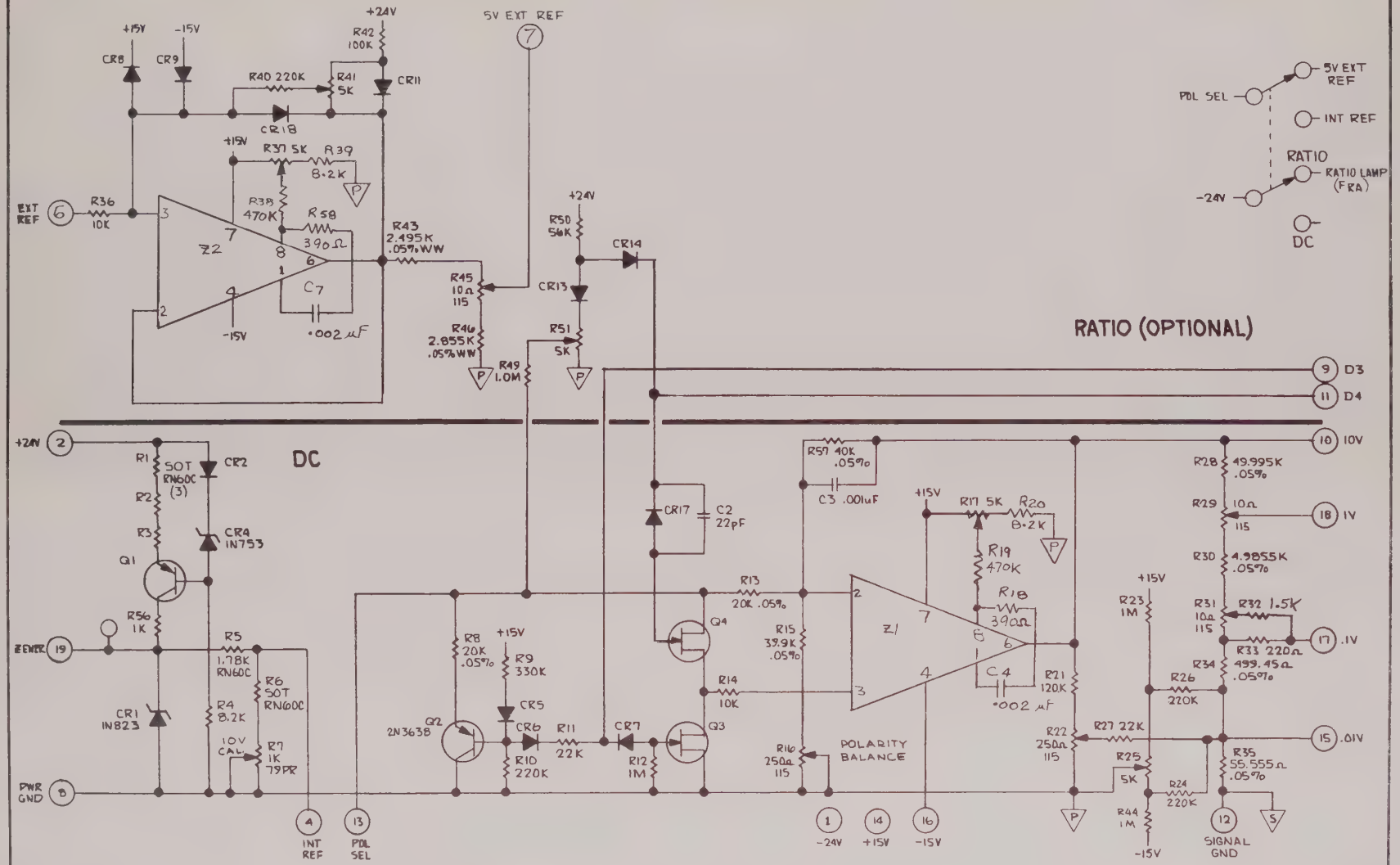
REFERENCE DESIGNATORS		
REF DESG.	LAST USED	DELETED (NOT TO BE RE-USED)
R (RES)	R83	R44, R45, R49, R50
C (CAP)	C32	C21, C22, C24, C25
CR (DIODE)	CR12	
Q (TRAN)	Q19	
Z (IC)	Z27	

NOTES, UNLESS OTHERWISE SPECIFIED.
1. ALL NPN'S ARE 2N3393
2. ALL DIODES ARE IN914
3. ○ INDICATES ELCO CONNECTION TO IO BD ASSEMBLY (100-436-)
4. (P) = POWER GND
5. FOR OPTION 'E' REMOVE C8 & C32. INSTALL THE CRYSTAL AND ALL COMPONENTS MARKED BY PARENTHESES ( ).

DORIC SCIENTIFIC

DIGITAL BD SCHEM

B. COLSON 6-1-69 · 6-3-69 · SHT 1 OF 1 · 100-628 09



REFERENCE DESIGNATORS

REF DES	LAST USED	DELETED (NOT TO BE RE-USED)
R (RES)	R58	R52, R53, R54, R55, R47 thru
CR (DIODE)	CR18	CR15, CR16, CR12, CR10
		CR3
C (CAP)	C7	C1, C5, C6
Q (TRANS)	Q9	Q5 THRU Q10

NOTES, UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL DIODES ARE IN914
3. ALL PNP TRAN'S ARE 2N4250
4. ALL NPN TRAN'S ARE 2N3877A
5. ALL FETS ARE U1742.
6. I.C. ARE MC1439G

	ORIGINAL ISSUE		
DORIC SCIENTIFIC	TITLE: REFERENCE SCHEMATIC		
TOLERANCE AND NOTES UNLESS NOTED	MATERIAL		
DRAFT: DYN-A-PAK	6-13-68	SCHEMATIC	
ENGR		TOOL	SCALE: NONE
DESIGN: PMH	6-15-68	NEXT ASSY	TYPE: SCHEMATIC
APPROVAL: Hans C Hans	6-15-68	SHT. 1 OF 1	DWG NO. 100-626 05

PULL UP REG — R19 1.5K — CR9 — CR10

PULL UP COM

HI REF — CR11

CR12

CR13 IN753A

DIGITAL GROUND

LO REF

J6

COMP SIDE	CRK'T SIDE	
A	1	SAMPLE COMPLETE
B	2	$\overline{OL}$
C	3	-POLARITY
D	4	DIGITAL GND
E	5	I_4
F	6	SAMPLE COMMAND
H	7	FUNC 2° OUT
J	8	I_3
K	9	8_3
L	10	4_3 (DEC-4)
M	11	2_3 (DEC-3)
N	12	PULL UP REG (DEC-2)
P	13	FUNC 2' OUT (DEC-1)
R	14	I_2
S	15	8_2 (HI REF)
T	16	4_2 (LO REF)
U	17	2_2
V	18	
W	19	-24V
X	20	PULL UP COM
Y	21	RANGE 2^2 OUT
Z	22	I_1
a	23	8_1
b	24	4_1
c	25	2_1
d	26	RANGE 1 IN — RANGE 2° OUT
e	27	RANGE 2 IN — RANGE 2' OUT
f	28	RANGE 3 IN — I_0
h	29	RANGE 4 IN — 8_0
J	30	RANGE 6 IN — 4_0
k	31	RANGE 5 IN — 2_0

ODC-1 (2 THRU 16, 18, 19 TYP TO THIS VIEW): R1-1 47K; CR1-1; Q1-1; R2-1 1M; C1-1 100PF; 8812; T1-1; -16V; Q2-1; R3-1 3.3K; R4-1 330Ω; -24V; CLK; A; B; C

ODC-2 ODC-3 ODC-4 ODC-5 ODC-6 ODC-7 ODC-8 ODC-9 ODC-10 ODC-11 ODC-12 ODC-13 ODC-14 ODC-15 ODC-16

Y_{10} Y_{20} Y_{40} Y_{80} Y_{11} Y_{21} Y_{41} Y_{81} Y_{12} Y_{22} Y_{42} Y_{82} Y_{13} Y_{23} Y_{43} Y_{83}

IDC-1 (2-3 TYP TO THIS VIEW): Q3-1 2N3415; CR2-1; CR3-1; CR4-1; R5-1 47K; R6-1 100K; T2-1; C2-1 .002; CR5-1; R7-1 220K; 220K; R8-1; R9-1 22K; -16V; Q4-1; Q5-1; R10-1; 24V; 3.3K; A; B; C; D; E

IDC-2 IDC-3

R_1 R_3 R_5 R_2 R_6 R_4

$R2^\circ$(ODC-23) $R2'$(ODC-24) $R2^2$(ODC-25)

ODC-17 (21 THRU 25 TYP TO THIS VIEW): R11-1 47K; R12-1 47K; Q6; CR6-1; CR7-1; Q7; R13-1 1M; C3-1 100PF; T3-1; 16V; Q8; R14-1 3.3K; -24V; R15-1 330Ω; CLK; A; B; C

ODC-18 ODC-19

$\overline{L_{OL}}$ $\overline{L_P}$

ODC-20 (21 THRU 25 TYP TO THIS VIEW): R16-1 47K; CR8-1; Q9-1; R17-1 1M; C4-1 100PF; T4-1; -16V; Q10-1; CLK; R18-1 330Ω; A; B; C; D

ODC-21 ODC-22 ODC-23 ODC-24 ODC-25

R18-2 110Ω; R18-3 110Ω; R18-4 110Ω

Y_{14}

SAMPLE COMPLETE; PULL UP COM; $\overline{O.L.}$; -POL; I_4; FUNC 2° OUT; FUNC 2' OUT; RNG 2° OUT; RNG 2' OUT; RNG 2^2 OUT

CR21 CR22 CR23 CR24 R44 470 R45 470 -20V -24V -16V

F_X F_Y

R46 22K R47 22K R48 22K

$R2^\circ$ (IDC-1) $R2'$ (IDC-2) $R2^2$ (IDC-3)

L1 240 uh -17V

-16V CLK

Q11 2N3415 Q12 2N3415 Q13 Q14 2N3415

R20 10K R21 10K R22 2.2K R23 2.2K R24 2.2K R25 2.2K R26 2.2K R27 100K R28 22K R29 22K R30 220K R31 220K R32 10K R33 100K R34 3.3K R35 22K R36 220K R37 2.2K R38 22K R39 33K R40 220K R41 68K R42 330K R43 47K

C5 150 PF T5 C6 220 PF C7 220 PF C8 .068 MFD C9 .01 MFD C10 .002 C11 220PF C12 = .033 FOR OPTION E, .22 FOR STD METERS. C13 .01 MFD COMMAND

CR14 CR15 CR16 CR17 CR18 CR19 CR20

Q15 Q16 Q17 Q18 Q19 Q20 Q21

T6

NOTE 8

-20V -24V

L_O M_1 INPUT

* C5 PART OF T5

NOTES; UNLESS OTHERWISE SPECIFIED
1. ALL DIODES ARE IN914
2. ALL NPN TRANS ARE 2N3393
3. ALL FETS ARE U206IE
4. → INDICATES CONNECTION TO REAR CONNECTOR
5. ○ INDICATES CONNECTION THRU ELCO PIN TO DIGITAL BD.
6. ⏚ INDICATES DIGITAL OUTPUT GND.
7. ▽ INDICATES ANALOG PWR GND.
8. C12 = .033 FOR OPTION E, .22 FOR STD METERS.

DEC-1 J6-P; DEC-2 J6-N; DEC-3 J6-M; DEC-4 J6-L; -24V R49 10K J6-W

REFERENCE DESIGNATORS		
REF DES	LAST USED	DELETED
CR	24	
C	13	
R	49	
Q	21	

DORIC SCIENTIFIC

I/O SCHEMATIC (CLOSURE FALSE OUTPUTS)

DRAFT PTR 4-28-69

SCHEMATIC

SHT. 1 OF 1

DWG NO 100-636 REV 07

RANGE SWITCHING

HI

ATTEN, FILTER & LIMITER

Q3

Q5

D7

L_R

Q4

D1

$\overline{L_1}$

LO

µV OFFSET SOURCE

L_0

D2

$M_1 + M_2$

D5

BUFFER AMP

G1

G10

G100

G1K

±10V

1V

.1V

.01V

S

ELECTRONIC OR MECHANICAL SWITCHES

E_B

E_C

Q17

R41

C12

INTEG. AMP

ZERO CROSSING AMP

Z3-1

ZERO SCHMITT TRIGGER

HOLD

Z3-5

L_Z

Z3-6

$\overline{L_Z}$

Z4-6

$\overline{L_R}$

Q22

AUTO-ZERO AMP

R64

C17

Q23

BI-POLAR REFERENCE VOLTAGE

SELECT POS REF

SELECT NEG REF

D4

D3

P2 OPTION ONLY

BCD TO DECIMAL RANGE DECODERS

REMOTE RANGE INFO (BCD)

$R2^0$ — 14

$R2^1$ — 11

$R2^2$ — 6

TO ATTEN RELAY

ATTEN RELAY DR

GAIN & REFERENCE CONTROL LINES (TO ELECTRONIC SWITCHES)

G1 G10 G100 G1K

'MV' NEON DEC 1 DEC 2 DEC 3 DEC 4

R1 R2 R1 R3 R2 R4 R5 R6 R5 R6 R1 R2 R5 R3 R6 R4

R1 R2 R3 R4 R5 R6

NOTES, UNLESS OTHERWISE SPECIFIED

= ELECTRONIC SWITCH

= INVERTER - DRIVER

= EMITTER FOLLOWER

= OR GATE.

DORIC SCIENTIFIC

LOGIC DIAGRAM (ANALOG BD)

DYN-A-PAK 7-7-68

SCHEMATIC

SHT 1 OF 1

100-640 00

SAMPLE RATE CONTROL (FRONT PANEL)

M.V. (ASTABLE, COL G2)

MONO 50MS

FF

FF

SAMPLE LIGHT

+170

CLOCK

Q8

CLOCK GATE

M_1 & M_2 GATE

MONO M_3 ($3\mu S$)

+ INDIC

- INDIC

MONO 600uS

Q6

M_1+M_2

Q9

POLARITY FF

L_R FF

MONO 100uS

HOLD LINE

RESET LINE

BCD COUNTER

GATED CLOCK

BCD STORAGE REGISTER

ALL DECADES ARE TYPICAL TO THE ONE SHOWN IN DETAIL.

STORE LINE

BCD TO DECIMAL DECODER/DRIVER

0 1 2 3 4 5 6 7 8 9

9 5 10 4 11 3 12 2 18 1

NIXIE

FF

FF

FF

Q14

Q19

OVERLOAD 'OL'

5TH DIGIT '1'

+170

+170

ORIGINAL ISSUE

DORIC SCIENTIFIC

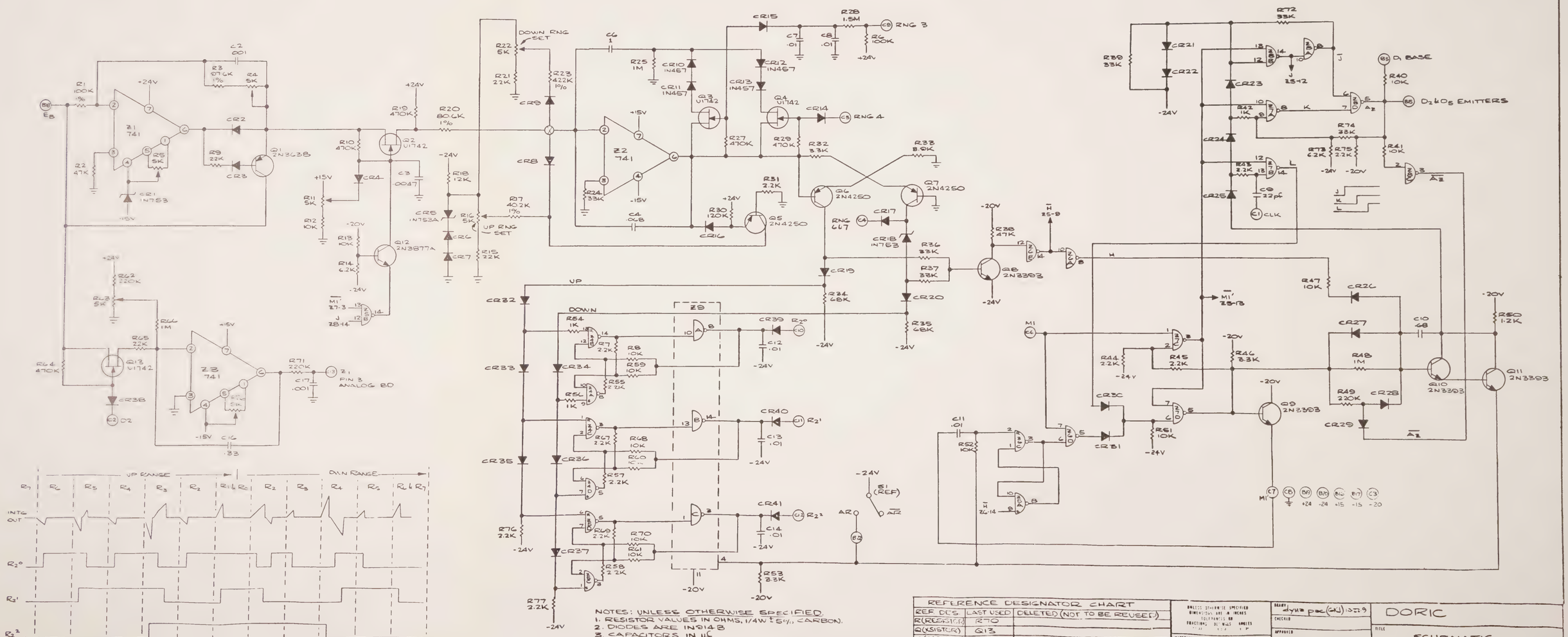
LOGIC DIAGRAM (DIGITAL BOARD)

DYNA PAK 7-5-68

SCHEM

SHT. 1 OF 1

100-641 00


UP RANGE
DWN RANGE
INTG OUT
NOTES: UNLESS OTHERWISE SPECIFIED.
1. RESISTOR VALUES IN OHMS, 1/4W ± 5%, CARBON.
2. DIODES ARE IN914B
3. CAPACITORS IN µF
4. GATES ARE MC717
5. ○ INDICATES ELCO CONNECTIONS
⊗ INDICATES SUMMING JUNCTION.

REFERENCE DESIGNATOR CHART		
REF DES	LAST USED	DELETED (NOT TO BE REUSED)
R (RESISTOR)	R70	
Q (XSISTOR)	Q13	
C (CAPACITOR)	C17	C1, C5, C15
CR (DIODE)	CR41	
Z (INT. CKT.)	Z9	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: DECIMALS .XX ± .01 FRACTIONS ± 1/64 ANGLES ± 1°

MATERIAL —

FINISH —

DRAWN dyw 8 DEC (74) 13:19

CHECKED

APPROVED

RELEASED

DESIGN ACTIVITY APPROVED

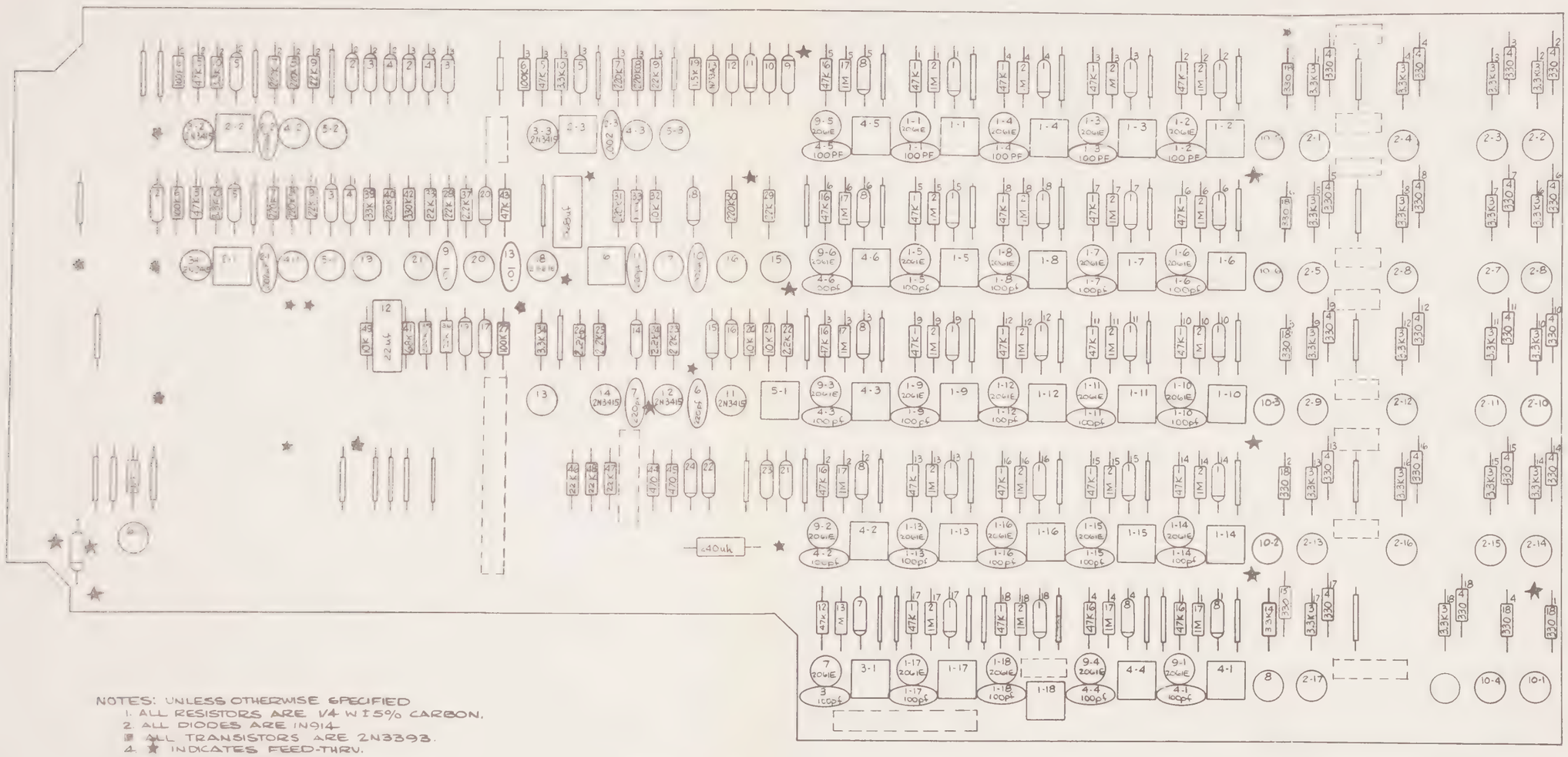
DORIC

TITLE

SCHEMATIC
AUTO RANGE

SIZE R | CODE IDENT NO | DRAWING NO 100-670 | REV 05

SCALE — | SHEET 1 OF 1



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/4 W ± 5% CARBON.
2. ALL DIODES ARE IN914
3. ALL TRANSISTORS ARE 2N3393.
4. ★ INDICATES FEED-THRU.
5. ALL FETS ARE U206IE
6. [ ] DENOTES ELCO PINS
7. DO NOT BREAK PLASTIC OFF THE ELCO'S, MOUNT ELCO'S PERPENDICULAR TO BOARD
8. ALL COMPONENTS MUST BE MOUNTED LESS THAN 3/8" ABOVE THE BOARD

QTY REQD PER DASH NO	SCHEM REF DESIGNATOR	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO	CODE IDENT OR MANUFACTURER	ZONE	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±1/32 DECIMALS ±.010 ANGLES ±1°

DRAWN: DNA PAC 7-7-9
CHECKED:
APPROVED:
RELEASED:
DESIGN ACTIVITY APPROVED:

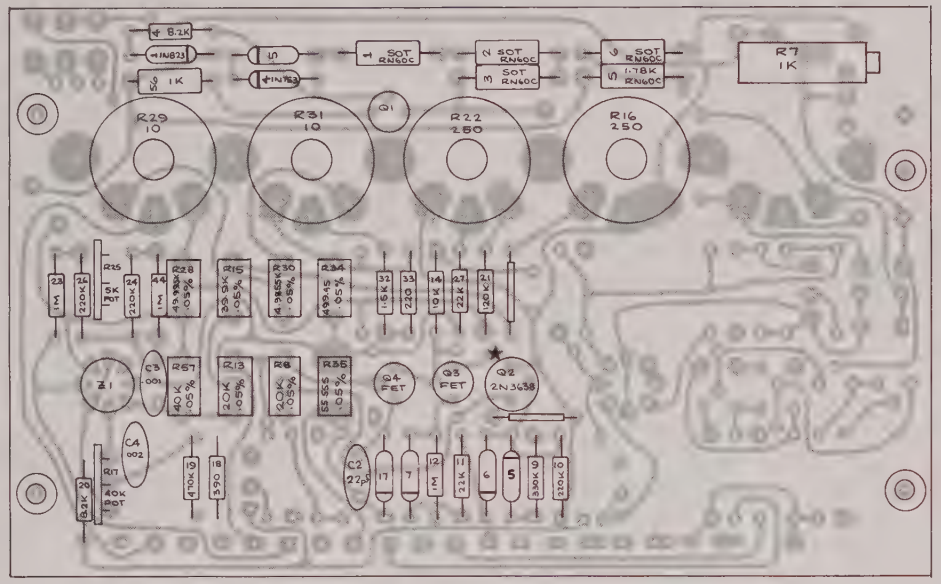
MATERIAL: ~
FINISH: ~

DORIC

TITLE: ASSEMBLY I/O (CLOSURE FALSE OUTPUTS)

SIZE	CODE IDENT NO.	DRAWING NO	REV
C		100-436	04

SCALE 2:1 SHEET 1/1



NOTE: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE 1/4 W ± 5% CARBON.
2. ALL FETS ARE U1742
3. ALL DIODES ARE IN914
4. ALL .05% RESISTORS ARE WIRE-WOUND
5. Z1 IS SC4715
6. ★ INDICATES FEED-THRU (1)
7. Q1 IS 2N3877A

QTY REQD PER DASH NO	SCHEM REF DESIGNATOR	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO	CODE IDENT OR MANUFACTURER	ZONE	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS DECIMALS ANGLES
± 1/32 ± .010 ± 2

DRAWN DYNA-PAC (GKJ 5/8/9)
CHECKED
APPROVED
RELEASED

MATERIAL

FINISH

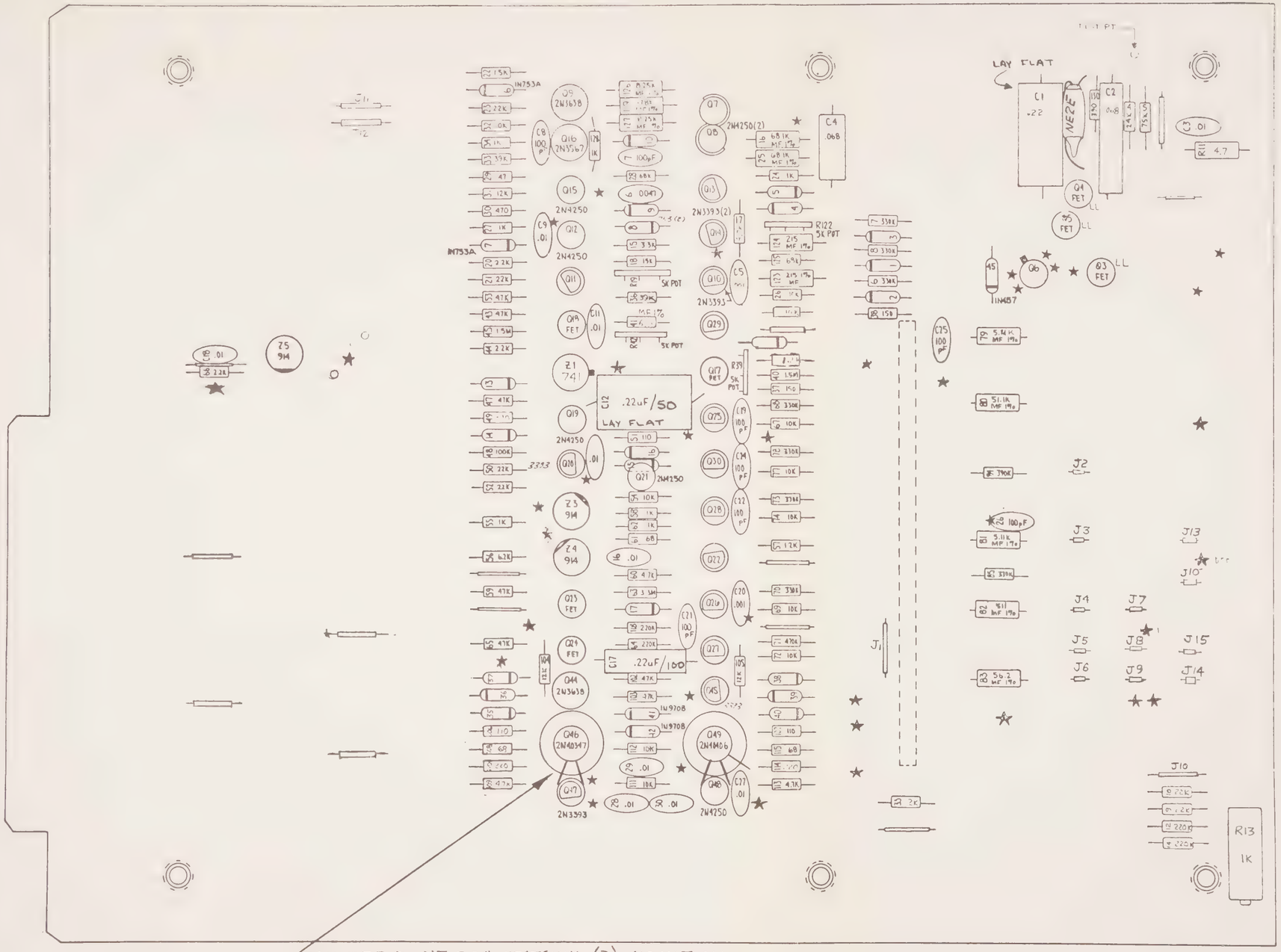
DESIGN ACTIVITY APPROVED

DORIC SCIENTIFIC

TITLE
ASSEMBLY
REFERENCE
BOARD

SIZE	CODE IDENT NO	DRAWING NO	REV
C			

SCALE 2:1 SHEET 1/1



ASSEMBLY NOTES

DES.	K1	K2	K3	K4
J1	REMOVE FOR RATIO OPTION			
J2				X
J3			X	
J4			X	
J5	X		X	X
J6	X			
J7			X	X
J8	X			X
J9	X		X	X
J10			X	
J11	X		X	X
J12				X
J13			X	
J14	X			X
J15	X		X	
Q6	DN267	SU2211	SU2211	SU2211

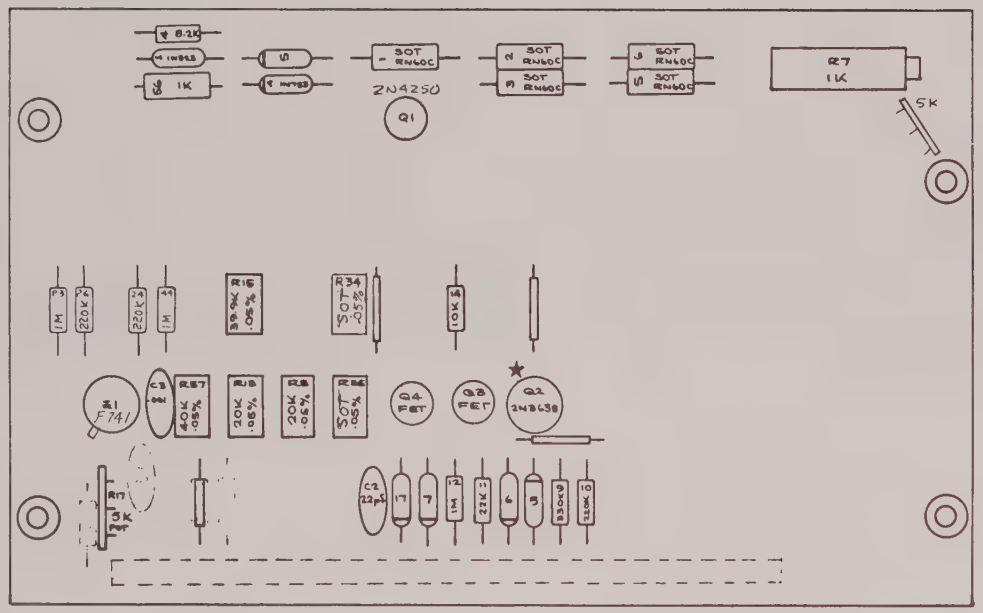
NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL FETS ARE U1742.
3. ALL DIODES ARE IN914.
4. ALL UNMARKED TRANSISTORS ARE 2N3877A.
5. DASH AREAS INDICATES ELCO PINS MOUNTED ON NEAR SIDE.
6. ★ INDICATES FEED-THRUS. (44)
7. MOUNT ELCO PINS AS IN DRAWING BELOW.

8. LL DENOTES LOW LEAK FET, (WHITE DOT)

WAKEFIELD NF-204 HEATSINK (2). MOUNT ON TRANSISTOR BEFORE MTG TRANSISTOR ON BOARD. POSITION HEATSINK ARMS TO AVOID HITTING COMPONENTS.

DORIC SCIENTIFIC		TITLE: ANALOG ASSEMBLY K1 Thru K4	
TOLERANCE AND NOTES UNLESS NOTED: FRAC ± 1/32, DEC ± .010, ANGULAR ± 1/2°. REMOVE ALL BURRS AND SHARP EDGES		MATERIAL: NOTED	
DRAFT: DYNA-PAC BC	4-16-69	FINISH	
CHECK		TOOL	SCALE: 2 TO 1
DESIGN		NEXT ASSY	TYPE: ASSEMBLY
RELEASE		SHT. 1 OF 1	DWG NO: 100-425 REV: 09
APPROVALS	DATE		



NOTE: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE 1/4 W ± 5% CARBON.
2. ALL FETS ARE U1741.
3. ALL DIODES ARE IN914.
4. ALL .05% RESISTORS ARE WIRE-WOUND
5. ★ INDICATES FEED-THRU (J)
6. Z1 IS F741
7. Q1 IS 2N4250
8. CAPACITANCES ARE IN μF
9. INSTALL ELCO PINS AS IN DRAWING B&low. LEAVE PLASTIC ON WHEN SOLDERING. DASHED BOX [ ] DENOTES ELCO PINS.

QTY REQD PER DASH NO	SCHEM REF DESIGNATOR	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO	CODE IDENT OR MANUFACTURER	ZONE	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/32 DECIMALS ± .010 ANGLES ± 2°

MATERIAL

FIN SM

DYNA-PAC (BKW 3-8-9)

CHECKED

APPROVED

RELEASED

DESIGN ACTIVITY APPROVED

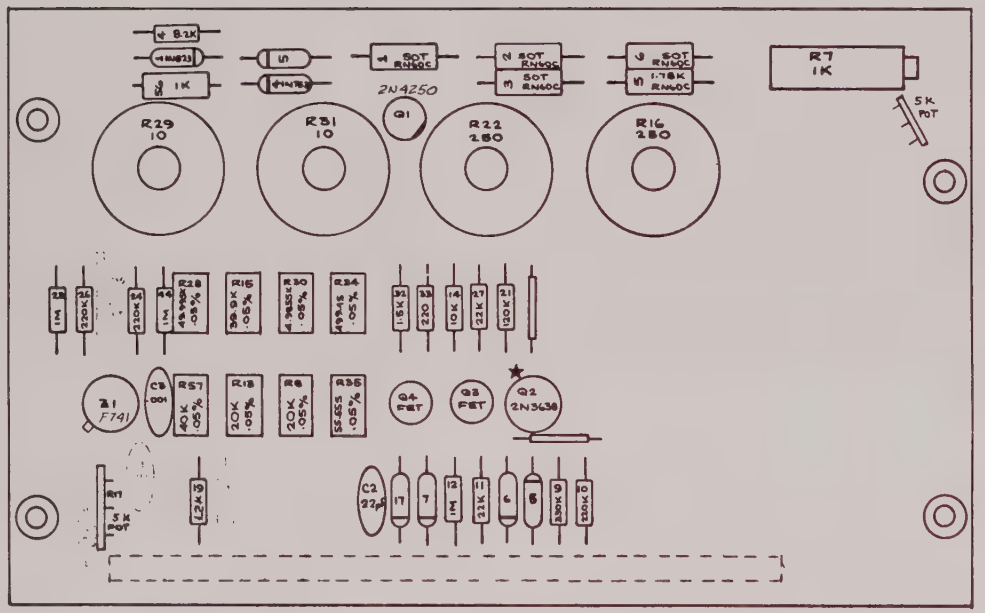
DORIC SCIENTIFIC

TITLE

ASSEMBLY REFERENCE BOARD SINGLE RANGE

SIZE	CODE IDENT NO	DRAWING NO
C		100-426

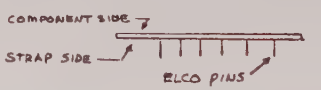
SCALE 2:1 SHEET 1/1



NOTE: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE 1/4 W ± 5% CARBON.
2. ALL FETS ARE U1742
3. ALL DIODES ARE IN914
4. ALL .05% RESISTORS ARE WIRE-WOUND
5. Z1 IS F741
6. ★ INDICATES FEED-THRU (1)
7. INSTALL ELCO PINS AS IN DRAWING BELOW, LEAVE PLASTIC ON WHILE SOLDERING.

DASHED BOX [- - - -] DENOTES ELCO PINS,



SCHEM REF DESIGNATOR	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO.	CODE IDENT NO MANUFACTURER	QTY

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES

MATERIAL

FINISH

NEXT ASSY DYNA-PAC (GKU 8/69)

CHECKED

APPROVED

RELEASED

CURRENT ACTIVITY APPROVED

DORIC SCIENTIFIC

TITLE

ASSEMBLY REFERENCE BOARD MULTI RANGE

SIZE C

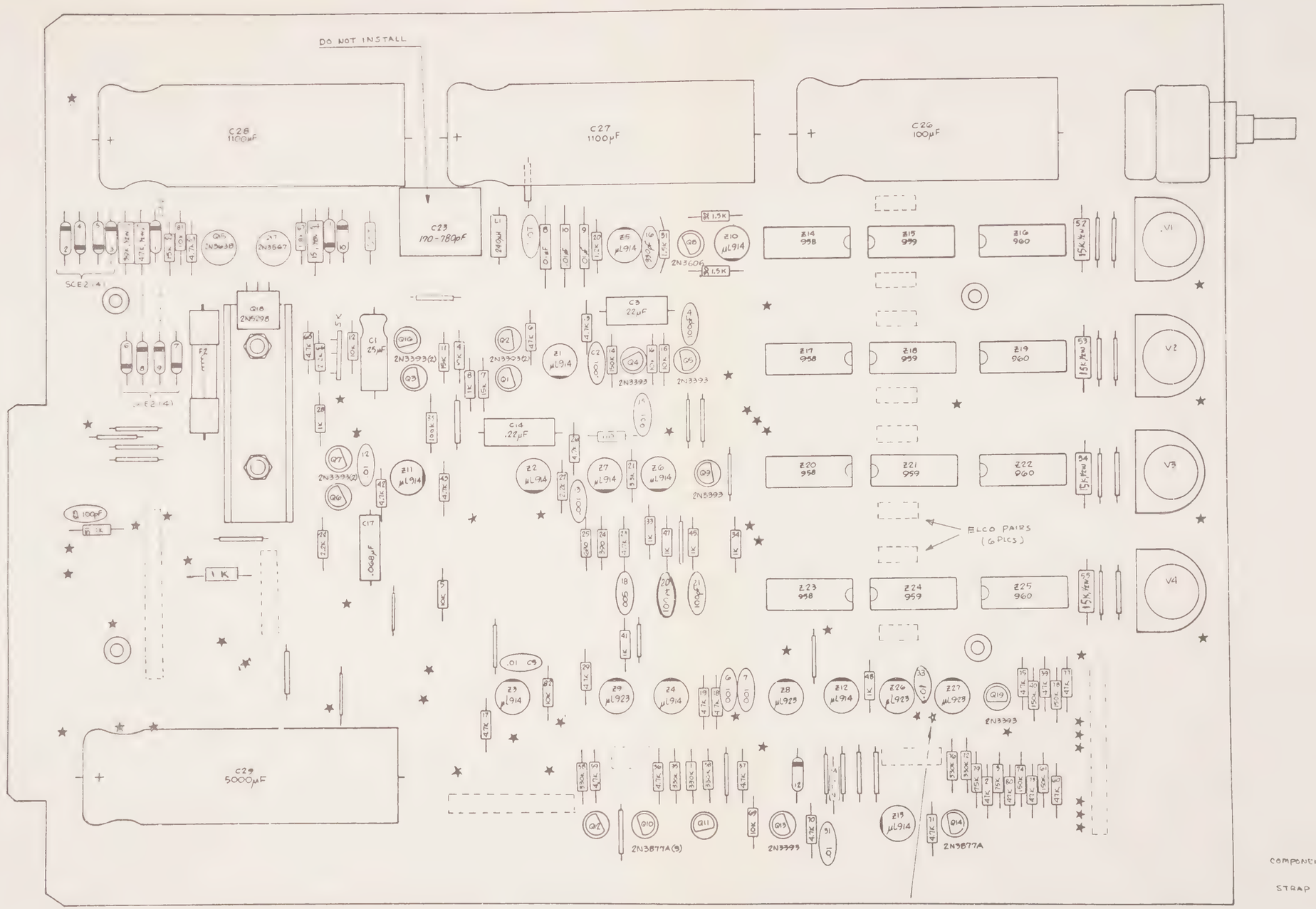
CODE IDENT NO

DRAWING NO 100-427

REV 00

2:1

SHEET 1/1



INSTALL THIS FEEDTHROUGH ONLY IF R14 IS TO BE BROUGHT TO Z12.

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE ¼W, 5% CARBON.
2. ALL DIODES ARE IN914
3. ★ INDICATES FEED-THRUS (47)
4. ALL ICs & TRANSISTORS TO BE INSTALLED 3/8" OR LESS FROM TOP OF BOARD.
5. MOUNT ELCO PINS AS IN DRAWING BELOW. LEAVE PLASTIC ON DURING SOLDERING. ALTERNATELY INSTALL ELCO PAIRS, SOLDER, REMOVE PLASTIC, THEN INSTALL THE REMAINING PAIRS.

QTY REQD PER DASH NO	SCHEM REF DESIGNATOR	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO	CODE IDENT NO MANUFACTURER	ZONE	IT NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/32 DECIMALS ±.010 ANGLES ±1°

MATERIAL

FINISH

DRAWN DYNA-PAC 9 MAY '69

CHECKED

APPROVED

RELEASED

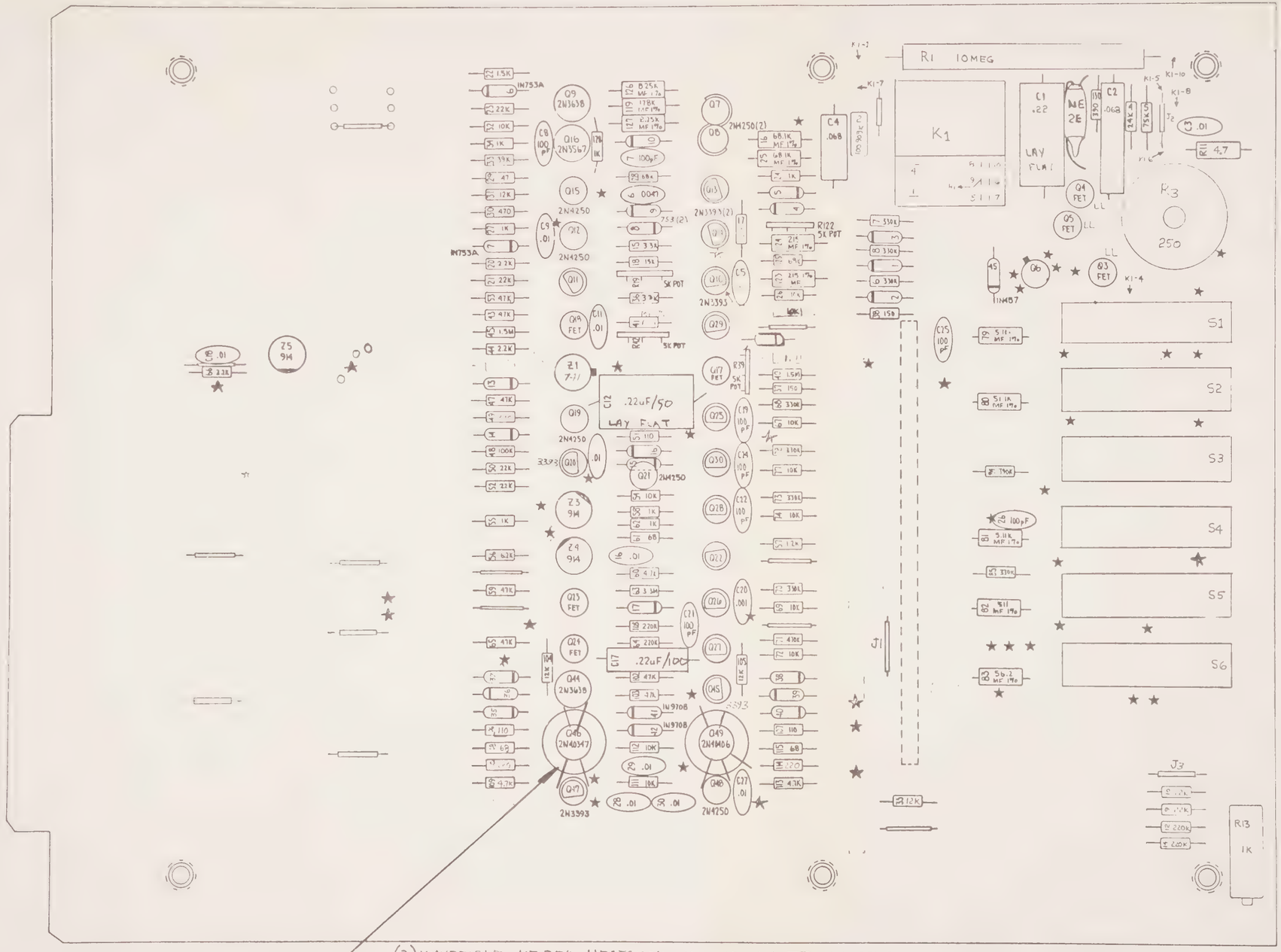
DESIGN ACTIVITY APPROVED

DORIC SCIENTIFIC

TITLE DIGITAL BOARD

SIZE | FSCM NO | DRAWING NO 100-423 | REV

SCALE FULL | SHEET 1 OF 1



(2) WAKEFIELD NF-204 HEATSINK - MOUNT ON TRANSISTOR BEFORE MTG TRANSISTOR IN BOARD. POSITION HEATSINK ARMS TO AVOID HITTING COMPONENTS.

ASSEMBLY NOTES

DES.	K6	K5A	K5
S1 THRU S6	INSTALLED		
S1 THRU S4		INSTALLED	
S3 THRU S6			INSTALLED
J2	NOT INSTALLED	NOT INSTALLED	"
J3	INSTALLED	"	"
R1	"	INSTALLED	NOT INSTALLED
R2	"	"	"
R3	"	"	"
R13	"	NOT INSTALLED	INSTALLED
K1	"	INSTALLED	NOT INSTALLED
Q6	DN 267	SU 2211	DN 267

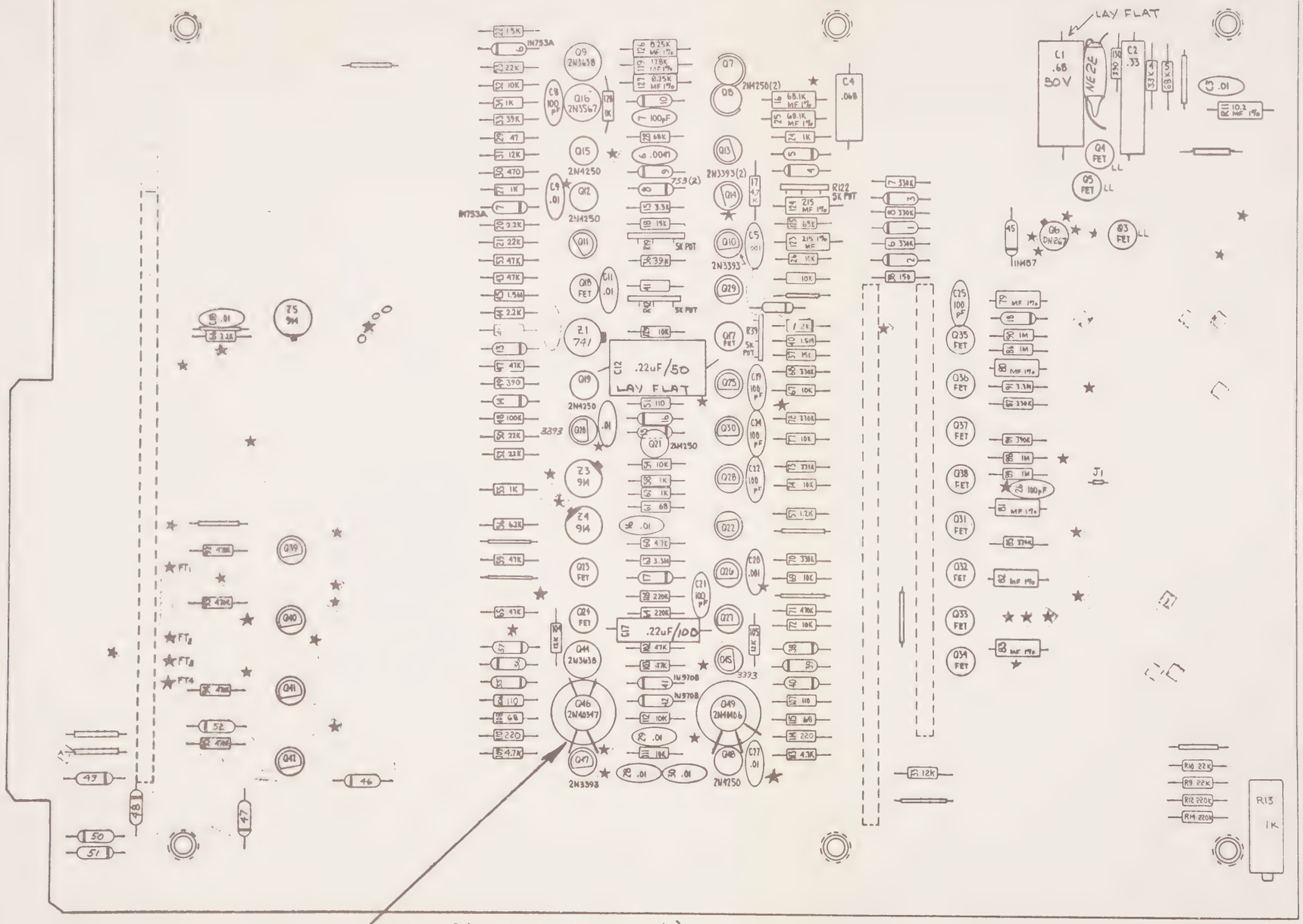
J1 REMOVE FOR RATIO OPTION

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL FETS ARE U1742.
3. ALL DIODES ARE IN914.
4. ALL UNMARKED TRANSISTORS ARE 2N3877A.
5. DASH AREAS INDICATES ELCO PINS MOUNTED ON NEAR SIDE.
6. ★ INDICATES FEED-THRUS.
7. MOUNT ELCO PINS AS IN DRAWING BELOW.

8. LL DENOTES LOW LEAK FET. (WHITE DOT)

DORIC SCIENTIFIC	TITLE: ANALOG ASSEMBLY K5 Thru K6
TOLERANCES AND NOTES UNLESS NOTED: FRAC ± 1/32, DEC ± .010, ANGULAR ± 1/2°. REMOVE ALL BURRS AND SHARP EDGES	MATERIAL: NOTED
DRAWN: DYNA PAC BC 4-16-69	FINISH
CHECK	TOOL
DESIGN	NEXT ASSY
RELEASE	SCALE 2 TO 1; TYPE ASSEMBLY
	SHT 1 OF 1; DWG NO 100-[illegible] 02



WAKEFIELD NF204 HEATSINK(2)- MOUNT ON TRANSISTOR BEFORE MOUNTING TRANSISTOR ON BOARD. POSITION HEATSINK ARMS AS SHOWN TO AVOID HITTING COMPONENTS

ASSEMBLY NOTES

DES.	T2	T3
R9	NOT INSTALLED	INSTALLED
R10	"	"
R12	"	"
R13	"	"
R14	"	"
R41	2.7 MEG.	619 K
R79	51.1 K	39.2 K
R80	280 OHMS	133 OHMS
R81	113 OHMS	56.2 OHMS
R82	56.2 OHMS	113 OHMS
R83	56.2 OHMS	56.2 OHMS
Q35	NOT INSTALLED	INSTALLED
Q36	"	"
Q37	"	"
Q38	"	"

	°C	°F	.1°	1	2	3	4
Fy	CR50	CR51	CR47				
Fx	CR48	CR49	CR52				
DEC ONLY				FT1	FT2	FT3	FT4

NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL FETS ARE U1742.
3. ALL DIODES ARE IN914.
4. ALL UNMARKED TRANSISTORS ARE 2N3877A.
5. DASH AREAS INDICATES ELCO PINS MOUNTED ON NEAR SIDE.
6. ★ INDICATES FEED-THRUS.(44)
7. MOUNT ELCO PINS AS IN DRAWING BELOW.

DORIC SCIENTIFIC

TOLERANCE AND NOTES UNLESS NOTED: FRAC ± 1/32, DEC ± .010, ANGULAR ± 1/2°. REMOVE ALL BURRS AND SHARP EDGES.

DRAFT DYNA-PAC BC 4-16-69

CHECK

DES ON

RELEASE

APPROVED

DESCRIPTION | DATE | DRAFT | APPR

TITLE: ANALOG ASSEMBLY T SERIES

MATERIAL: NOTED

FINISH

TOOL

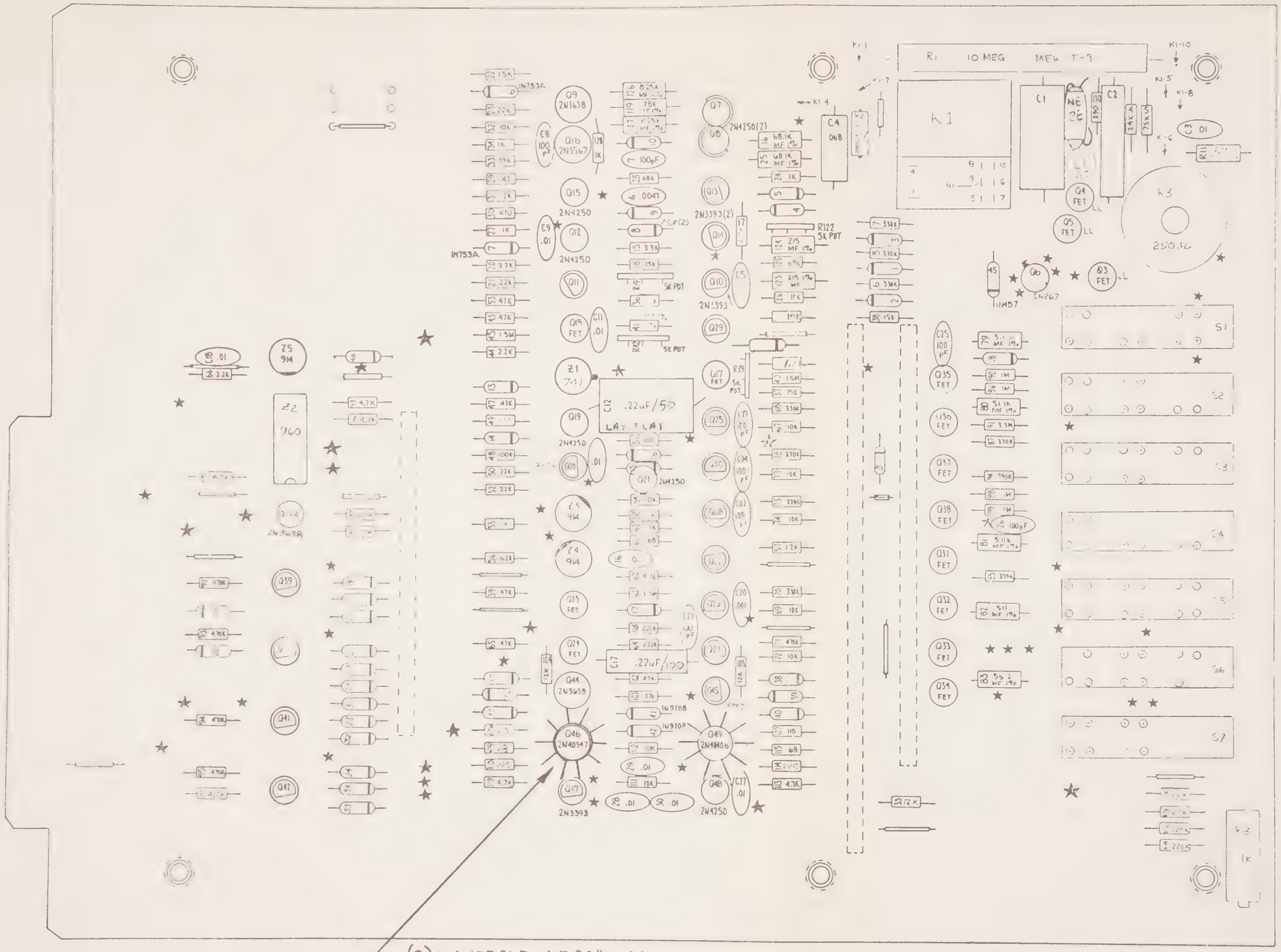
NEXT ASSY

SCALE: 2 TO 1

TYPE: ASSEMBLY

SHT. 1 OF 1

DWG NO: 100-430 REV: 02



(2) WAKEFIELD NF 204 HEATSINK - MOUNT ON TRANSISTOR BEFORE MOUNTING TRANSISTOR ON BOARD. NOTE POSITION OF HEATSINK ARMS TO AVOID HITTING COMPONENTS.

ASSEMBLY NOTES

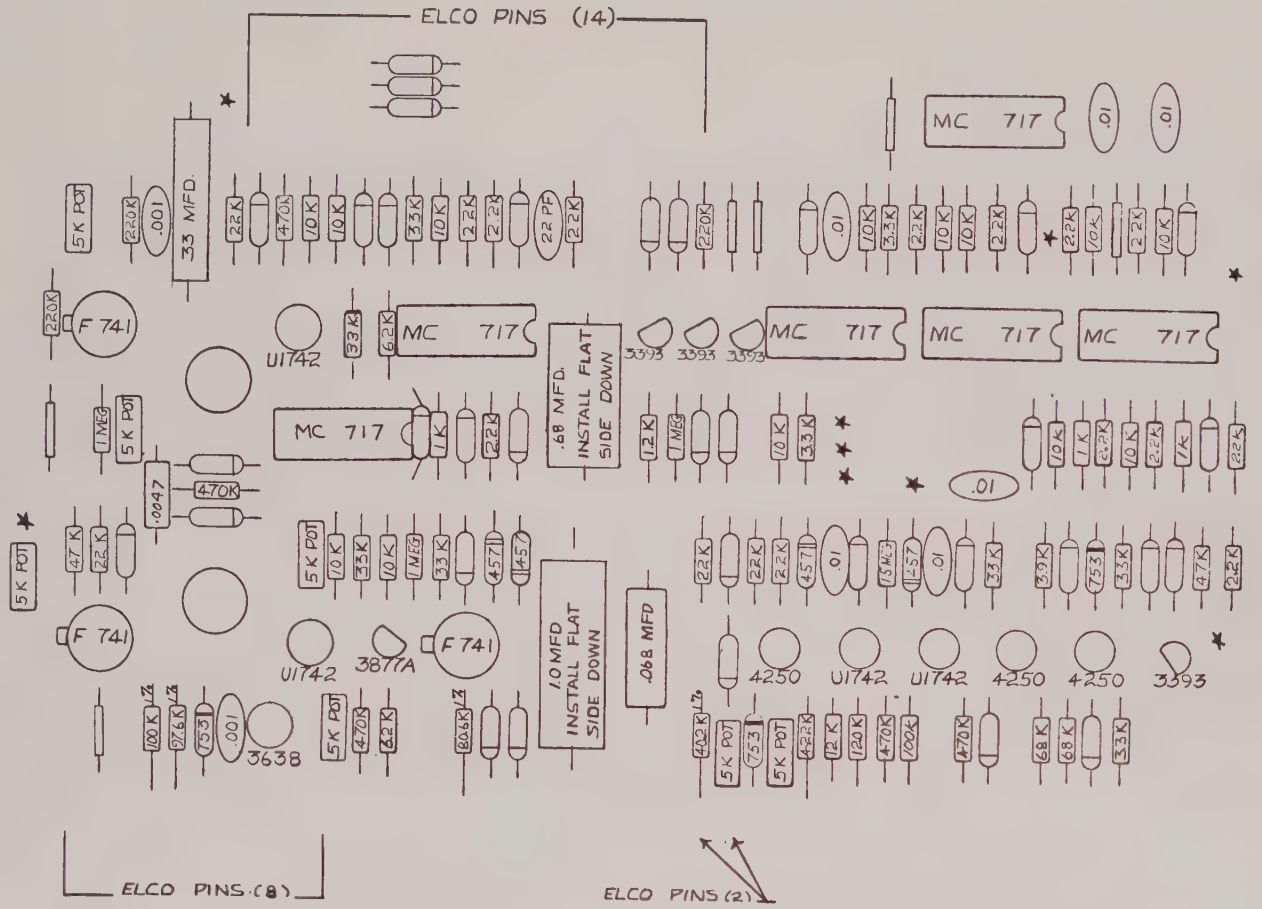
DES.	P2	P2A
C1	.22MFD	.1MFD
C2	.068MFD	.033MFD
S7	NOT INSTALLED	INSTALLED

NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL FETS ARE U1742.
3. ALL DIODES ARE IN914.
4. ALL UNMARKED TRANSISTORS ARE 2N3877A.
5. DASH AREAS INDICATES ELCO PINS MOUNTED ON NEAR SIDE.
6. ★ INDICATES FEED-THRUS.(44)
7. MOUNT ELCO PINS AS IN DRAWING BELOW.

8. LL DENOTES LOW LEAK FET. (WHITE DOT)

DORIC SCIENTIFIC	ANALOG ASSEMBLY P2 & P2A	
TOLERANCE AND NOTES UNLESS NOTED	MATERIAL NOTED	
DRAFT DYNA PAC BC 4-16-69	FINISH	
CHECK	TOOL	SCALE 2 TO 1
DESIGN	HEAT ASST	TYPE ASSEMBLY
RELEASE	SHT 1 OF 1	DWG NO 100/31



COMPONENT SIDE

STRAP SIDE

INSTALL ELCO PINS FACING DOWN. LEAVE PLASTIC STRIP ON ELCO PINS WHILE SOLDERING.

NOTES: ALL UNMARKED DIODES ARE 914 TYPE

✱ DENOTES A FEED THRU.

—— DENOTES A JUMPER.

ALL 5K POTS FACE RIGHT SIDE OF BOARD. ALLOW 1/16 SPACING BETWEEN 5K POT AND BD. PULL ALL COMPONENTS AS CLOSE TO BD. AS POSSIBLE.

QTY REQD PER DASH NO	SCHEM REF DESIGNATOR	PART OR IDENT NO	ELEC IDENT NO MFR ACRONYM

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES

DRAWN DYNA PAC 10-6-9

CHECKED

APPROVED

RELEASED

MATERIAL

FINISH

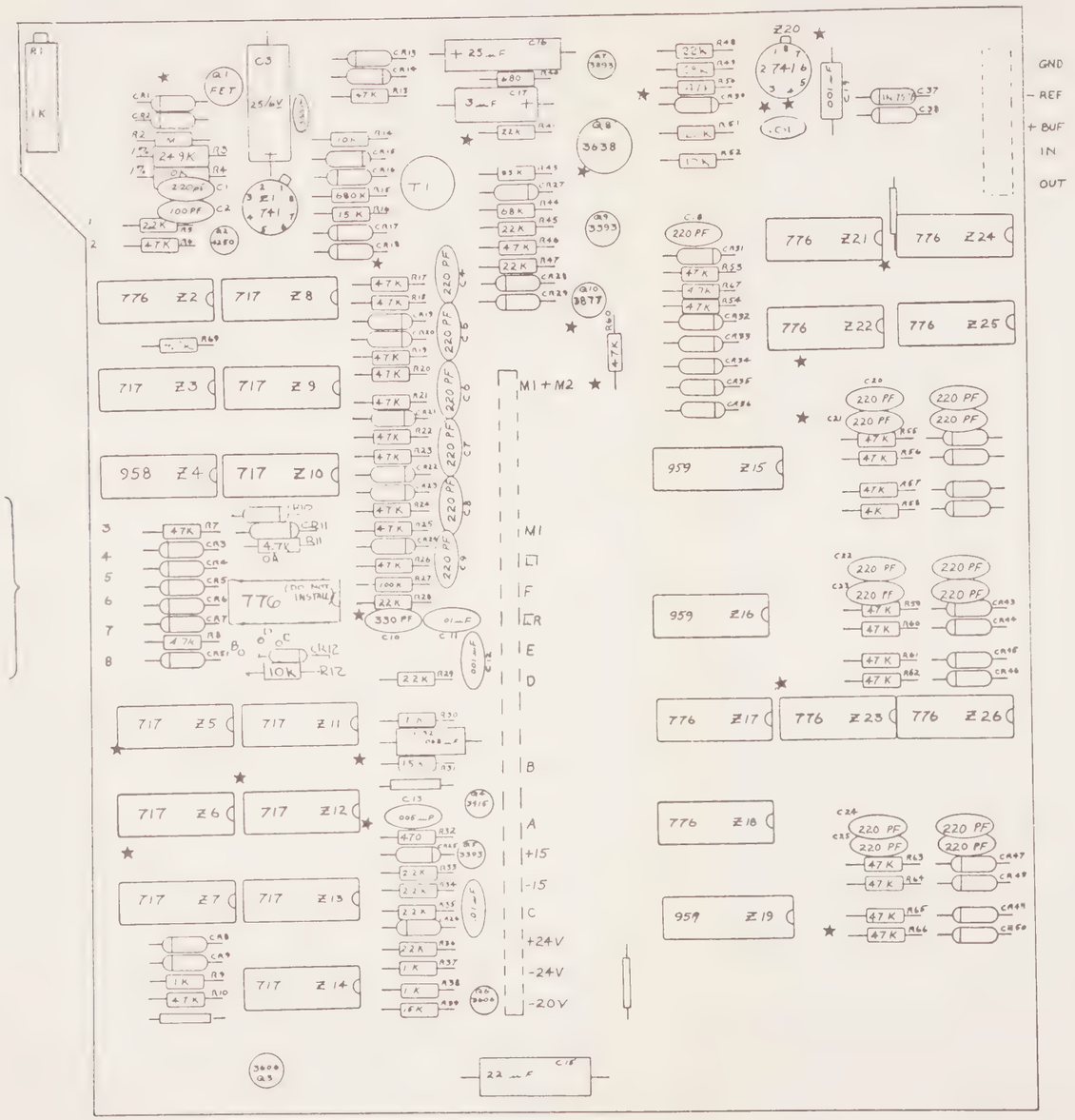
DESIGN ACTIVITY APPROVED

TITLE DS 100 P2A AUTO RANGE - ASSY DWG

SIZE C

DRAWING NO 100-472-03

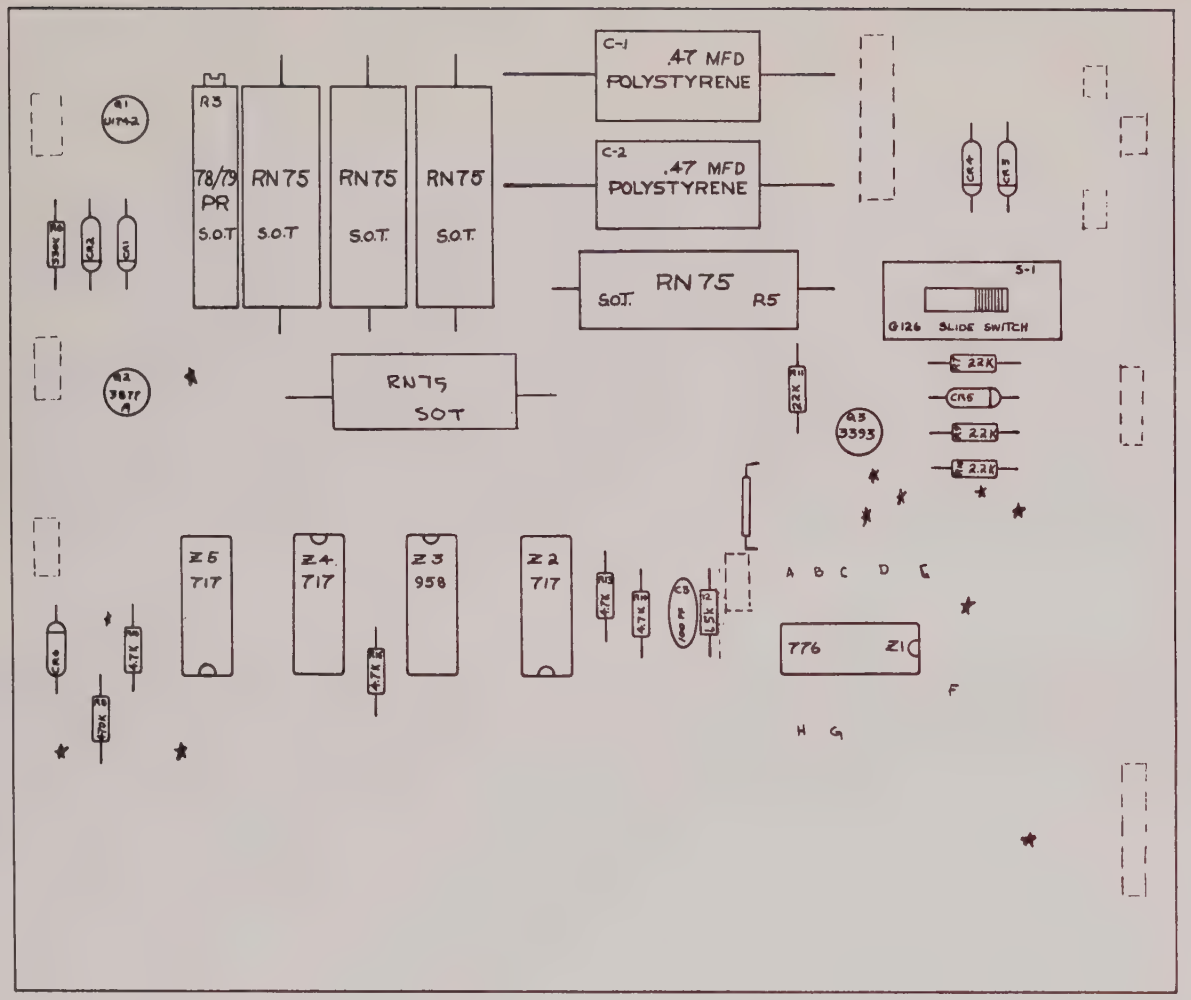
SHEET 1 OF 1



NOTES: UNLESS OTHERWISE INDICATED

1. ALL REBISTOR VALUES ARE IN OHMS @ 1/4W, 5% CARBON
2. ALL DIODES ARE IN914
3. DASH AREAS INDICATE ELCO PINS MOUNTED ON NEAR SIDE
4. ★ INDICATES FEED THRUS (Z1)
5. INSTALL ELCOS FROM COMPONENT SIDE.

	DYNA PAC (H) 11.13.9	DORIC
	CHECKED	ASSEMBLY DRAWING
	APPROVED	HORSE POWER OPTION
	RELEASED	
	DESIGN ACTIVITY APPROVED	D 100-494 02
		1 OF 1



NOTES: UNLESS OTHERWISE INDICATED;
1. ALL RESISTORS ARE IN OHMS @ 1/4W, 5%
2. ALL DIODES ARE IN914
3. "S.O.T." COMPONENTS ARE SELECT ON TEST.
4. ELCOS MTD. FROM CIRCUIT SIDE.

SCHEM REF DESIGNATION	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO	CODE IDENT OR MANUFACTURER	ZONE	ITEM NO
QTY REQD PER DASH NO	PARTS LIST				

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ±1/32 DECIMALS .0 ± .0 ANGLES ±1°

MATERIAL

FINISH

DRAWN DYNA PAC (JH) 10-15-9

CHECKED

APPROVED

RELEASED

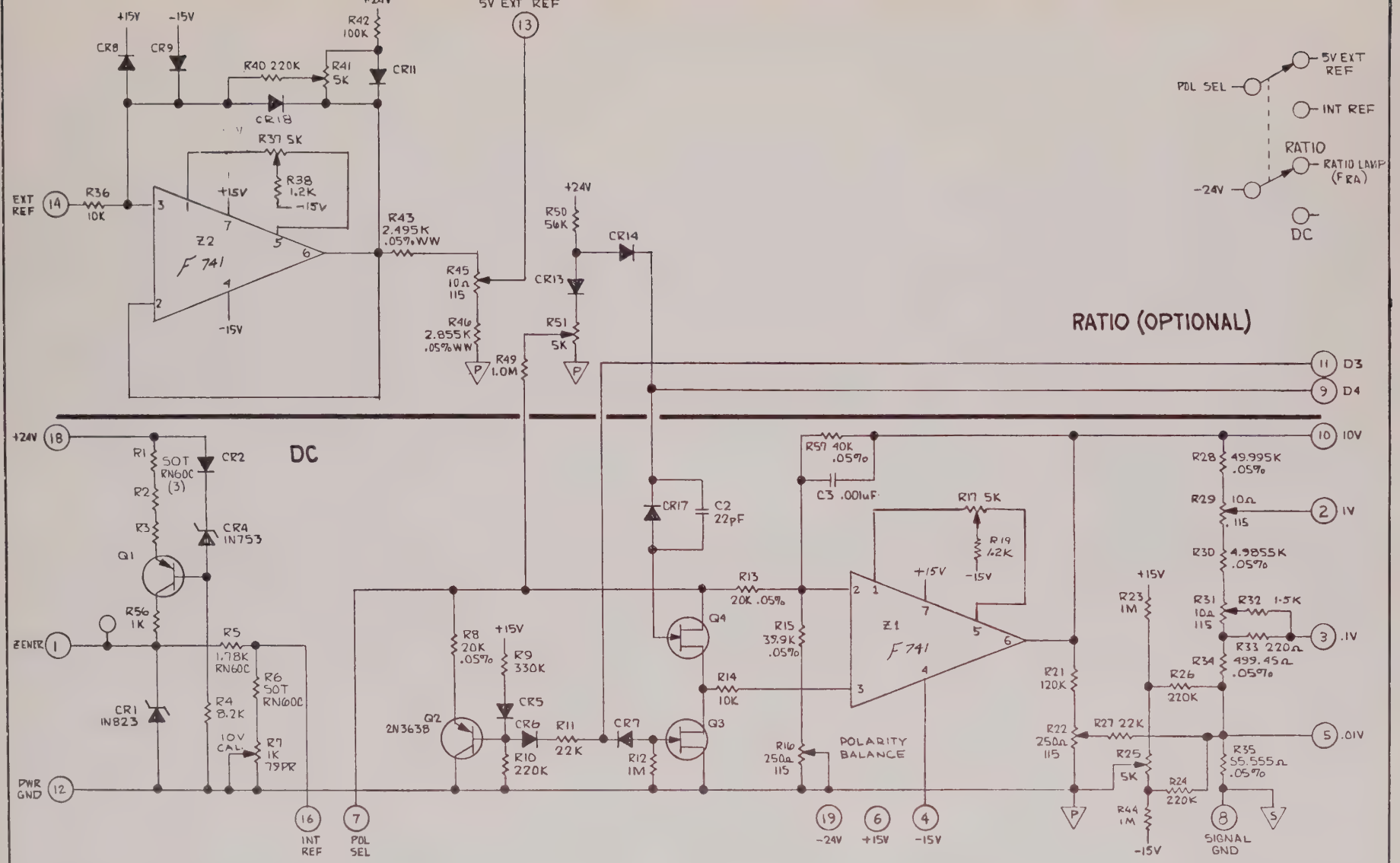
DESIGN ACTIVITY APPROVED

DORIC

TITLE
2 SPEED INTEGRATOR
ASSY. DWG.

SIZE	CODE IDENT NO	DRAWING NO	REV
C		100-495-01	

SCALE 2:1 SHEET 1 OF 1



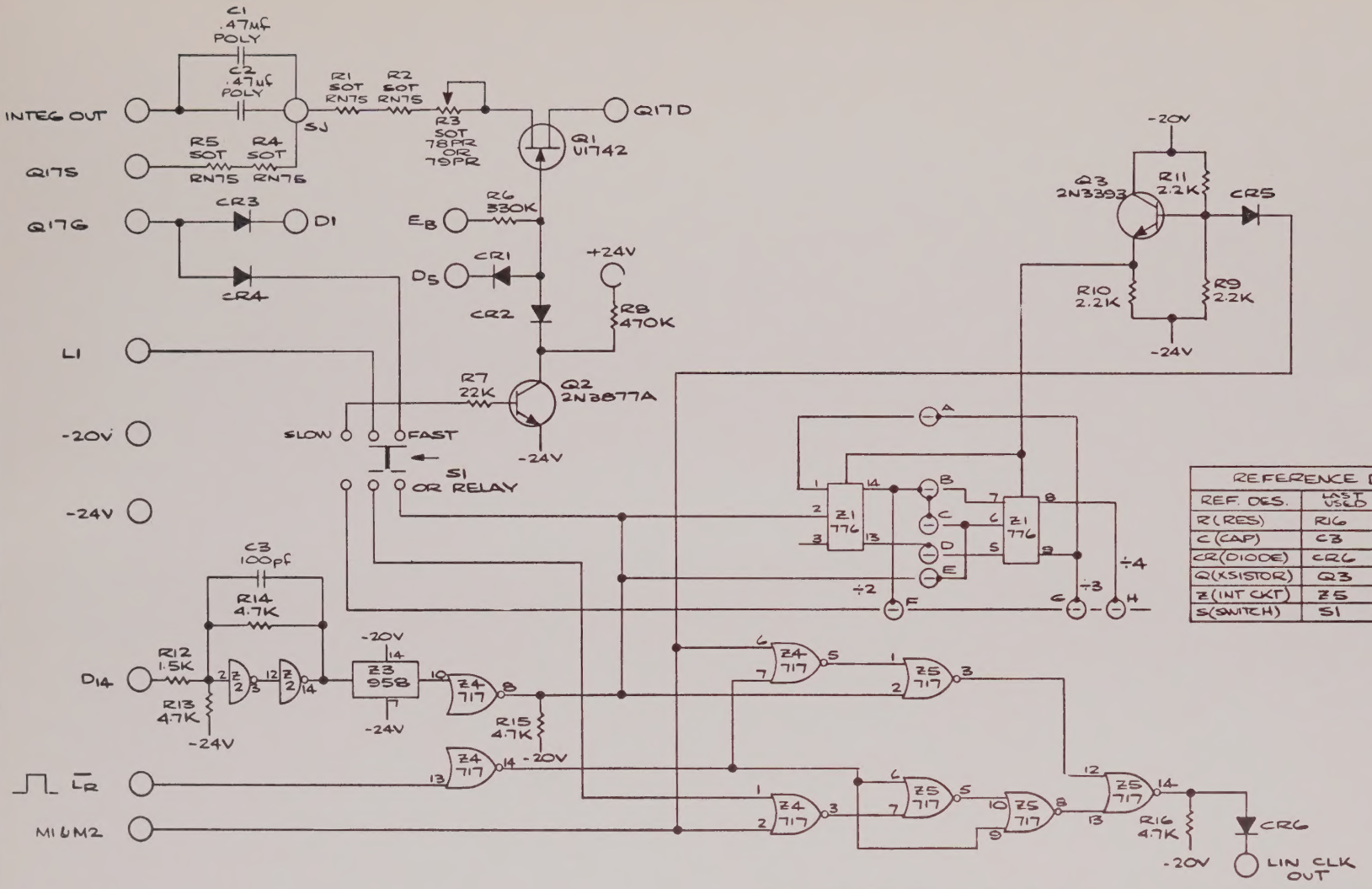
REFERENCE DESIGNATORS

REF DES	LAST USED	DELETED (NOT TO BE RE-USED)
R (RES)	R58	R52, R53, R54, R55, R47, R48
		R18, R58, R33, R20
CR (DIODE)	CR18	CR15, CR16, CR12, CR10, CR3
C (CAP)	C7	C1, C5, C6, C4, C7
Q (TRANS)	Q9	Q5 THRU Q10

NOTES, UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL DIODES ARE 1N914
3. ALL PNP TRAN'S ARE 2N4250
4. ALL NPN TRAN'S ARE 2N3877A
5. ALL FETS ARE U1742.
6. I.C. ARE SC 4715

	ORIGINAL ISSUE		
DORIC SCIENTIFIC	REFERENCE SCHEMATIC		
DRAFT DYN-A-PAK	6-13-68		
DESIGN DMH	6-15-68	SCALE NONE	
		TYPE SCHEMATIC	
	SHT. 1 OF 1	DWG NO. 100-626	DASH 08



REFERENCE DESIGNATORS		
REF. DES.	LAST USED	DELETED NOT TO BE REUSED
R (RES)	R16	
C (CAP)	C3	
CR (DIODE)	CR6	
Q (XSISTOR)	Q3	
Z (INT CKT)	Z5	
S (SWITCH)	S1	

NOTES: UNLESS OTHERWISE SPECIFIED:
1. RESISTOR VALUES IN OHMS, 1/4 W ± 5% CARBON.
2. DIODES ARE IN914.
3. S.O.T. COMPONENTS ARE SELECT ON TEST.
4. Z2 IS TYPE 717
5. ○ INDICATES ELCO CONNECTION

QTY REQD PER DASH NO	SCHEM REF DESIGNATOR	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO	CODE IDENT OR MANUFACTURER	ZONE	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ±1/32 DECIMALS ±.010 ANGLES ±1°

DRAWN dyna pac (GKJ) 10-22-9
CHECKED
APPROVED
RELEASED

MATERIAL —

FINISH —

DESIGN ACTIVITY APPROVED

DORIC

TITLE
SCHEMATIC
2 SPEED INTEGRATOR

SIZE	CODE IDENT NO	DRAWING NO	REV
C		100-687-	00

SCALE — SHEET 1 OF 1

www.manualsplus.com
1008992